POWER PLANT ENGINEERING

Established Over 32 Years

VOL. XXXII CHICAGO, FEBRUARY 15, 1928 No. 4

Contents of this Issue

Page

Steam Turbine Tests at Moores Park Station. By J. E. Woodwell. Illustrated 222

Operating Experiences with 12-Lb. Pressure. By John Anderson. Illustrated 229

Industrial Plant Effects Marked Saving. Illustrated..... 233

Boiler Tests with Unit Mills at Cahokia. By E. H. Tenney. Illustrated 238

Progress in Oil and Gas-Power Engineering..... 239

Welded Plate Construction Used for Machinery. Illustrated 241

Steam Generator, Feature at New Staley Plant. Illustrated 242

Automatic Switching of Incoming A. C. Lines. By A. E. Anderson. Illustrated 249

Procedure in Starting Up a New Generator—III. By Marin Phillips. Illustrated 253

Generated vs. Purchased Electrical Energy. By H. O. Swoboda. Illustrated 254

Boulder Dam and Umatilla Hearings Under Way. By Wingrove Bathon 257

Letters Direct from the Plant: Counterflow and Unaflow Non-Condensing Engine Economies. Diesel Power Growing in Importance. Always Heat Parts into Which You Pour Babbit. Vibration Cured by Weighing Machine Parts. Use Wheel-Cutter for Waterline Glasses. Coating Affects Pipe and Chimney Friction. Rivet from Fuse Plug Serves Emergency. Drumming of Boilers Stopped by Steam Jets. Illustrated.. 259

Questions and Answers: Cards for Criticism. Steam Plant Operation. Inertia Governor vs. Centrifugal Governor. Are "Automatic Injectors" Automatic? Illustrated 263

Editorial Comment: A Mark for the Industrial Plant. Testing and Design of Bleeder Turbines. Difficulties of High Pressure Operation..... 264

Off Duty 265

Latest Power Plant Practice. Illustrated..... 266

Portable Compressor Serves Many Purposes. Illustrated.. 977

Kelly Co. Announces New Valve. Illustrated..... 977

Cutler-Hammer Makes Large Motor-Operated Field Rheostats. Illustrated 977

Michael Pupin Receives Washington Award..... 278

News Notes 278

Books and Catalogs..... 279

Power Plant Construction News..... 280

Published on the 1st and 15th of each Month by the

Technical Publishing Co., 53 West Jackson Blvd., Chicago

New York Office, 150 Nassau Street

Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1928, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

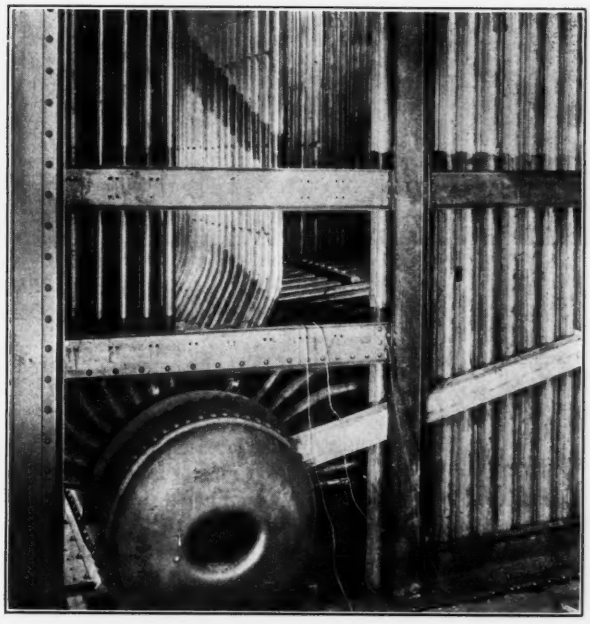
Member, Associated Business Papers, Audit Bureau of Circulations.

Circulation of this Issue 23,800

EDITORIAL STAFF

ARTHUR L. RICE, Editor — R. E. TURNER, Managing Editor — A. W. KRAMER, Associate Editor

CHESTER R. EARLE, Associate Editor — RICHARD R. MORRIS, Associate Editor — EDWARD J. KUNZE, Associate Editor



The Slaughter of the Innocents

HERE IS A DEATH trap for B.t.u.'s. Picture, if you can, tender-hearted reader, a poor, innocent B.t.u., forced from a snug home in a block of coal, where it slumbered for a million years, into this terrible steel contraption where the temperature is well over 2000 deg. —a veritable Hades, in fact—without even the mitigating influence of an understanding devil. Picture this unfortunate heat unit with many of his equally unfortunate brothers, frantically striving to escape, rushing hither and thither, pell mell, head over heels towards an exit that does not exist, always crashing headlong against the cruel steel bars of the cage which surrounds them on all sides. Imagine all this with a gang of villainous combustion engineers on the outside, rubbing their hands with glee.

Isn't that enough to bring tears to one's eyes? Yet, that is what goes on every day in steam generators now in operation. The one shown is installed in the plant of the A. E. Staley Mfg. Co., described in this issue. Over 163 million innocent B.t.u.'s perish in this furnace every hour, but even this does not satisfy the diabolical instincts of the combustion engineers. They want more, and with every additional capture they chalk up new figures on their efficiency charts. Most disgustful, to say the least.

Steam Turbine Tests at Moores Park Station

By J. E. Woodwell*

AT THE MOST EFFICIENT LOAD, THE 20,000-KW. TURBINE GENERATES A KW-HR. ON 11,592 B.T.U., APPROXIMATELY 6.5 PER CENT BELOW THE MANUFACTURER'S GUARANTEE

IN ACCORDANCE WITH the contract entered into when the equipment was purchased, acceptance tests of the 20,000-kw. unit No. 3 and the 1500-kw. auxiliary unit of the City of Lansing Municipal Power Plant at Moores Park were made to determine whether the guarantees of economy and capacity made by the turbine and condenser builders were being fulfilled.

This plant now comprises three main turbo-generator units; unit No. 1 rated at 10,000 kw., unit No. 2 rated at 15,000 kw. and unit No. 3, which was recently installed and tested, rated at 20,000 kw. A general view of the station with unit No. 1 in the foreground is shown in Fig. 2. They are all three-phase, 60-cycle, 13,200-v., 1800-r.p.m. machines, manufactured by the Allis-Chalmers Mfg. Co., and operate at 250 lb. gage, 200 deg. F. superheat and 29 in. referred vacuum. Unit No. 1 is equipped with a condenser of the same make, while units No. 2 and 3 have condensers manufactured by C. H. Wheeler Mfg. Co.

Units No. 1 and No. 2 are supplemented by two Allis-Chalmers house turbines, one of 500 kw. and the other of 750-kw. capacity. Each of these units is combined with an Allis-Chalmers variable vacuum barometric condenser used to secure a suitable feedwater heat balance. The third unit is supplemented by an Allis-Chalmers 4400-v. auxiliary condensing turbine of 1500 kw. capacity, equipped with a C. H. Wheeler surface condenser.

Four extraction nozzles are provided on the 20,000-kw. turbine which is of straight reaction type with blading passages proportioned for extraction. Three nozzles are now connected to the closed feedwater heaters and are in use. Two of these heaters are located in the turbine room below the basement floor level, adjacent to the foundation of the turbine as shown in Fig. 10, and the high pressure heater is located in the boiler room. As shown in the cross section of the turbine, Fig. 1, the low pressure element is built on the uni-directional double flow principle.

Spring supports are provided for the 26,000-sq. ft., two-pass surface condenser, which is made up of 4730 1-in. o.d., No. 16 B.w.g. tubes, 21 ft. 3 in. long. Two circulating pumps with a capacity of 23,000 g.p.m. operating singly, or 17,500 g.p.m. when operated together, are driven by direct connected 125-hp. slip ring motors, equipped with drum controllers for variable speed. Duplicate condensate pumps are each driven by 60-hp. direct connected motors and vacuum pump requirements are taken care of by steam jets.

Generator air coolers are in duplicate and are equipped with connections so that either condensate from the turbine, river water or both may be used for cooling. Separate and distinct coils are used for different water connections so as to avoid any possibility of contaminating the boiler feedwater with raw water and at the same time to provide an ample reserve for cooling under all operating conditions. The generator cooling system is

*Consulting Engineer, New York, N. Y.

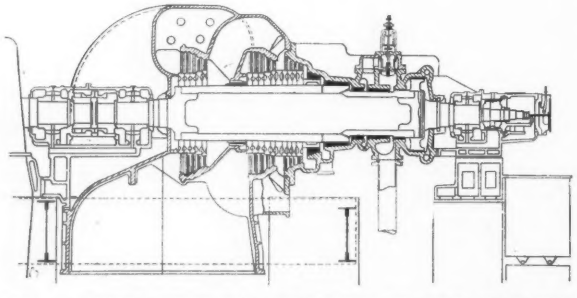


FIG. 1. CROSS SECTIONAL DRAWING OF THE 20,000-KW. TURBINE SHOWING THE CONSTRUCTION OF THE UNI-DIRECTIONAL DOUBLE FLOW LOW PRESSURE ELEMENT

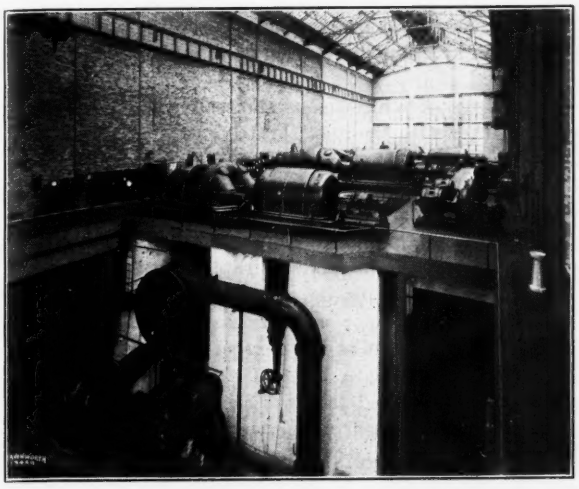


FIG. 2. GENERAL VIEW OF THE TURBINE ROOM OF MOORES PARK STATION. THE NEW 20,000-KW. UNIT IS IN THE BACKGROUND

of the closed recirculating type. Computations show the quantity of air passing through the generator as approximately 50,000 cu. ft. per min.

Tests were conducted and carried out in strict accordance with the consulting engineer's specifications and the builder's guarantee. The load consisted of the regular commercial demand on the system, supplemented by three water rheostats, one operating at 13,200 v., the other at 4400 v. Regulation of the load on the 20,000-kw. unit during the tests was effected with precision by this means and by operating another unit in parallel, both turbines being at all times under full governor control.

Test Made at Four Specified Points

Heat consumption of the unit was determined at four separate loads, which were specified and for which guarantees were made by the manufacturer. Tests were conducted by the author as consulting engineer for the Board of Water and Electric Light Commissioners with the co-operation of W. H. Collins, Electrical Engineer, and L. E. Dunkelberger, Chief Test Engineer for the City municipal plants. All tests were witnessed by the manufacturers' representatives and log sheets, taken in triplicate by the observers, were distributed to the parties concerned.

In order that the tests be performed and conducted in accordance with all the rules and regulations of the A. S. M. E. test codes, special attention was paid to details concerning the methods of testing and location of instruments. The sequence of load points was taken in such a way that the low load test was performed first and the following higher loads afterwards. The purpose of this was to avoid any argument as to the possible effect which may be introduced through residual heat in the turbine itself. A test was performed in the morning and afternoon of each day and the load carried by the unit prior to the test was below that value which was held constant during the official period.

TABLE I. SUMMARY OF TEST RESULTS ON THE 20,000-KW. TURBINE

Load on unit, kw.	Heat Consumption By test B.t.u. per kw-hr.	Heat Consumption Guaranteed B.t.u. per kw-hr.	Margin better than guarantee per cent	Final feedwater temperature as specified in contract deg. F.
10,388	12,730	13,420	5.15	215
15,421	11,789	12,520	5.80	232
18,034	11,529	12,350	6.15	237
20,176	11,823	12,460	5.15	239

Calculations on each two-hour test were made immediately after the test was run, by engineers representing

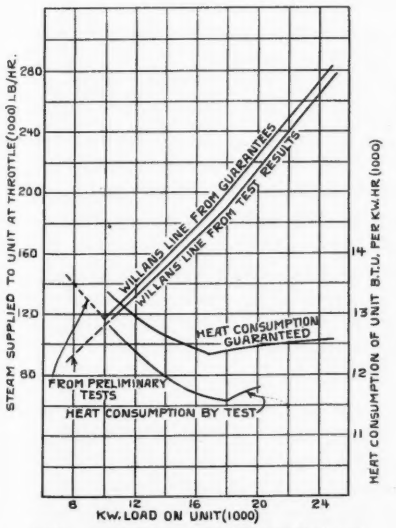

STEAM SUPPLIED TO UNIT AT THROTTLE (1000) LB/HR.
HEAT CONSUMPTION OF UNIT B.T.U. PER KW.HR (1000)
KW. LOAD ON UNIT (1000)
WILLANS LINE FROM GUARANTEES
WILLANS LINE FROM TEST RESULTS
HEAT CONSUMPTION GUARANTEED
FROM PRELIMINARY TESTS
HEAT CONSUMPTION BY TEST

FIG. 3. HEAT CONSUMPTION OF THE 20,000-KW. TURBINE SHOWING A COMPARISON OF THE GUARANTEED AND TEST RESULTS

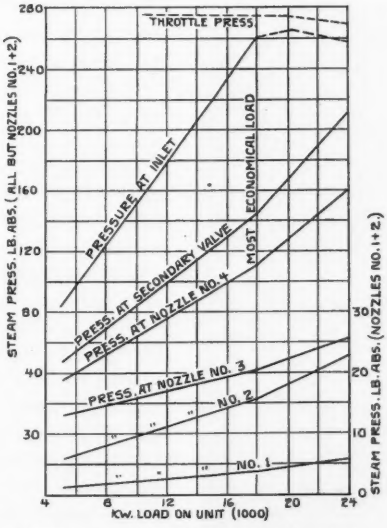

STEAM PRESS. LB. ABS. (ALL BUT NOZZLES NO. 1+2)
STEAM PRESS. LB. ABS. (NOZZLES NO. 1+2)
KW. LOAD ON UNIT (1000)
THROTTLE PRESS.
PRESSURE AT INLET
MOST ECONOMICAL LOAD
PRESS. AT SECONDARY VALVE
PRESS. AT NOZZLE NO. 4
PRESS. AT NOZZLE NO. 3
" " " NO. 2
" " " NO. 1

FIG. 4. VARIATIONS IN THE PRESSURE AT VARIOUS PARTS OF THE TURBINE FOR DIFFERENT LOADS

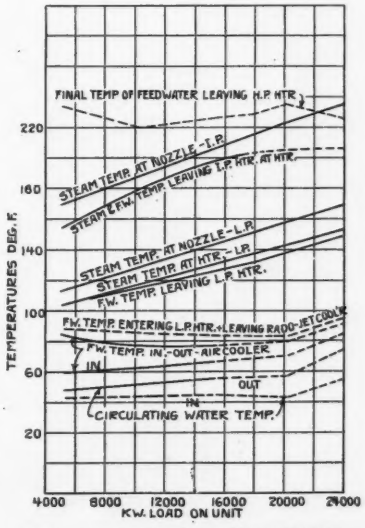
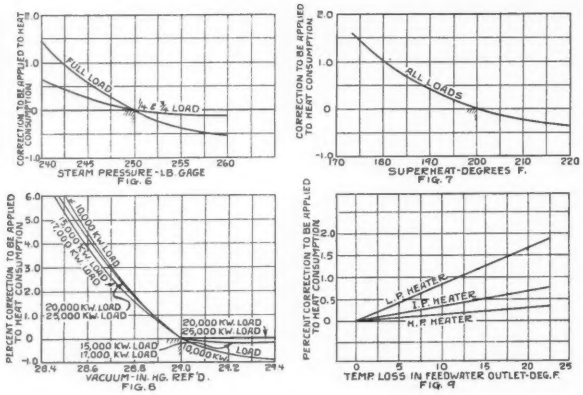

TEMPERATURES DEG. F.
KW. LOAD ON UNIT
FINAL TEMP OF FEEDWATER LEAVING H.P. HTR.
STEAM TEMP. AT NOZZLE - I.P.
STEAM & F.W. TEMP. LEAVING I.P. HTR. AT HTR.
STEAM TEMP. AT NOZZLE - L.P.
STEAM TEMP. AT HTR. - L.P.
F.W. TEMP. LEAVING L.P. HTR.
F.W. TEMP. ENTERING L.P. HTR. & LEAVING RADO-JET COOLER
F.W. TEMP. IN. - OUT - AIR COOLER
IN
OUT
IN
CIRCULATING WATER TEMP.

FIG. 5. TEMPERATURE VARIATIONS AT DIFFERENT POINTS PLOTTED AS A FUNCTION OF THE LOAD



FIGS. 6, 7, 8, 9. CORRECTION CURVES FOR USE IN CORRECTING THE HEAT CONSUMPTION WHEN CONDITIONS ARE OTHER THAN THOSE COVERED IN THE CONTRACT

the Board and the turbine manufacturers. Tabulation of the test summary is given in Table I and the results are set forth graphically in Fig. 3, together with the total steam line plotted as a function of the load, for both test results and guarantee. These total steam test points show close agreement with Willan's Line, which applies to a turbine operating straight condensing with all steam throttled by one regulating valve.

Extracted Steam Varies Practically As a Straight Line

Although this unit was operating under extraction conditions, Willan's Line would, in all probability, hold fairly accurate, provided the extraction steam varied as some straight line function of the load. This is practically true for all fractional loads below the most efficient point. Extracted steam from the low and intermediate pressure nozzles is automatically governed by the saturation temperature of the steam, and although the quantity extracted for the high pressure heater was controlled manually, the quantity was quite regular as a function of the load.

Stage pressures at various stages and extraction nozzles, together with the inlet throttle pressures are plotted as a function of the load in Fig. 4. All of these stage pressure readings follow straight lines for all loads with a break or change in slope above the most economical point. Feedwater, extraction nozzle and circulating water temperatures are shown graphically by Fig. 5.

Heat consumptions do not include steam or power used by accessories or auxiliaries. The loads are the true electrical output at the generator terminals, including energy required in the field for excitation, as well as the steam required to drive the direct connected exciter. They are based on the weight of steam admitted to the main turbine at the throttle, the condensate being

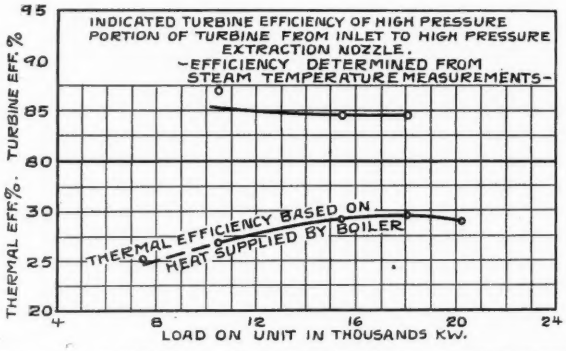

INDICATED TURBINE EFFICIENCY OF HIGH PRESSURE PORTION OF TURBINE FROM INLET TO HIGH PRESSURE EXTRACTION NOZZLE.
-EFFICIENCY DETERMINED FROM STEAM TEMPERATURE MEASUREMENTS-
THERMAL EFFICIENCY BASED ON HEAT SUPPLIED BY BOILER
THERMAL EFF.% TURBINE EFF.%
LOAD ON UNIT IN THOUSANDS KW.

FIG. 11. RANKINE CYCLE EFFICIENCY OF THE HIGH PRESSURE TURBINE ELEMENT AND THE THERMAL EFFICIENCY OF THE ENTIRE TURBINE

heated from a temperature of 79 deg. F. (corresponding to a saturation steam temperature of 29 in. of vacuum) to temperatures not less than those given in the last column of Table I, in the flow cycle consisting of the following equipment: A generator air cooler using only condensate; Radojet inter and after condenser and stage extraction heaters and evaporators, requiring saturated steam from the main turbine.

Guarantees are based on the extraction heaters operating with a terminal difference of 7 deg. F. and the evaporator operating continuously, evaporating 60 deg. F. make-up water at a rate of 3 per cent of the steam required for the main turbine. The heat consumption does not include radiation losses from the feedwater equipment. When conditions of steam pressure, superheat and vacuum differed from standard conditions, they were corrected in accordance with the curves shown in Fig. 6, 7, 8 and 9, as provided by the manufacturers and included in the contract.

During the tests the feedwater flow cycle differed somewhat from that given above. A direct connection was made from the high pressure extraction nozzle into the low pressure heater as shown in Fig. 12. This arrangement bypasses the evaporators which ordinarily receive steam from the high pressure extraction nozzle, drain to the intermediate pressure heater and deliver vapor to the high pressure heater, which acts as an evaporator condenser. Quantities of steam and water given in Fig. 12 are for a load of about 18,000 kw.

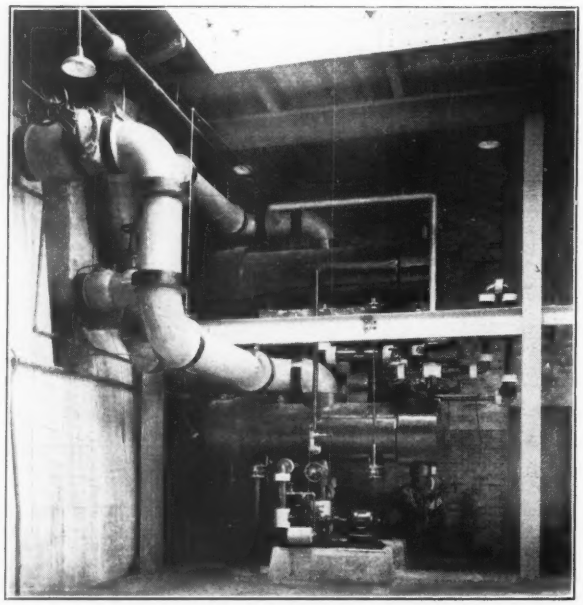


FIG. 10. A GENERAL VIEW OF THE LOW AND INTERMEDIATE BLEEDER HEATERS AS INSTALLED NEAR THE TURBINE FOUNDATION

Guarantee Results Exceeded at All Loads

Results of the tests show that the main unit met the guarantees of the builder at every load by a substantial margin. The tests were run under favorable circumstances for accurate measurements, load, steam pressure, superheat and all factors which were in any way under the control of the operating staff being maintained constant at all times. The low heat consumption obtained from test results is substantiated by test observations of the efficiency of the high pressure ends of the turbine, which were obtained by other methods.

Referring to Fig. 11, the Rankine cycle efficiency ratio of the high pressure element is plotted as a function of the load for the three tests made below the most economical point. Efficiency ratios were determined from temperature measurements of the steam at two points in the turbine and show an efficiency ratio as high as 84.5 per cent. These efficiencies apply to the turbine only; however, converting these turbine efficiencies to comparative values of generator output, so as to include generator losses, results in an efficiency of above 80 per cent. The thermal efficiency of the unit based on the feedwater flow cycle used is shown in the same figure.

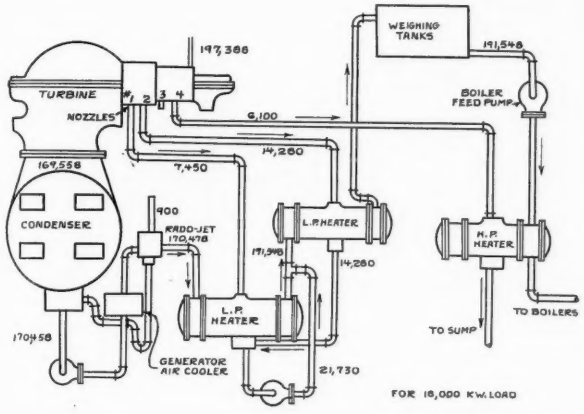


FIG. 12. FLOW DIAGRAM OF THE COMPLETE UNIT, THE FIGURES GIVEN SHOWING THE STEAM OR WATER QUANTITIES FLOWING IN VARIOUS PARTS OF THE SYSTEM WITH AN 18,000-KW. LOAD ON THE TURBINE

Condensate leaving the hotwell of the condenser is increased by the amount of steam supplied by the Radojet. This condensate was also increased at the outlet of the low pressure heater by the amount of drained condensate and condensed steam extracted to the two lower pressure heaters. As shown in Fig. 12, the drained condensate is pumped back from the lower pressure heater hotwell into the main condensate line below the low pressure heater by small centrifugal pumps, shown under the heater in Fig. 10.

Drained condensate from the intermediate pressure heater drops into the hotwell of the low pressure heater, and, because of the lower pressure, part of it flashes into steam. The source of water supply to the water sealed turbine glands located at both high and low pressure ends of the turbine shell, was condensate taken from the condensate line between the Radojet condenser and the low pressure heater. The internal leakage was drained back into the condenser, thus making a self-contained recirculating water system.

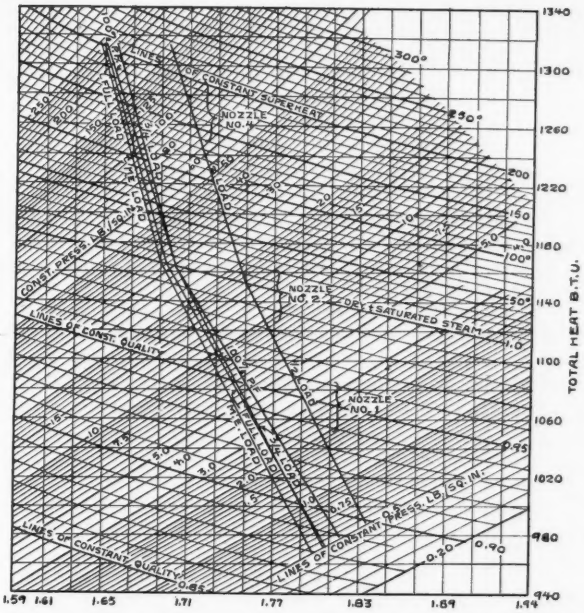


FIG. 13. ENTROPY DIAGRAM SHOWING THE EXPANSION OF STEAM THROUGH THE 20,000-KW. TURBINE UNDER DIFFERENT LOAD CONDITIONS

Total condensate passed into the weighing tank, plus the quantity extracted into the high pressure heater is equal to the steam delivered to the throttle of the turbine after, of course, taking into account the external leakage and steam supplied to the Radojet. The quantity of steam extracted into the high pressure heater was calculated by means of the heat temperature rise of the weighed condensate and the known heat available in the extracted steam. After weighing, the water was

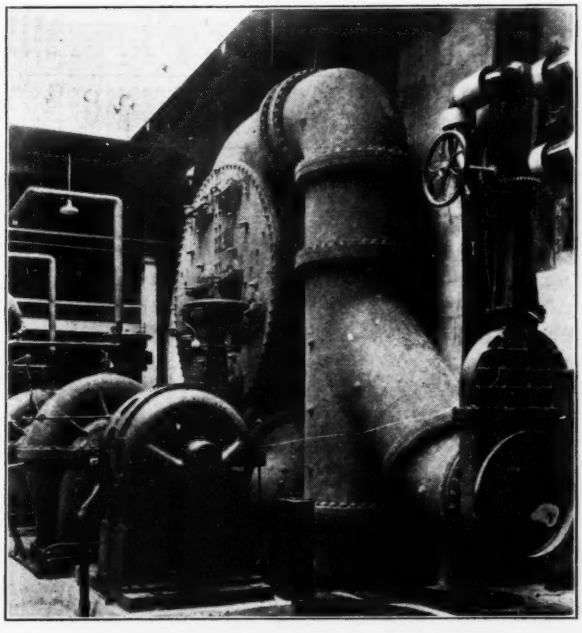


FIG. 14. A GENERAL VIEW OF THE CONDENSER AND CIRCULATING PUMPS OF THE 20,000-KW. UNIT

TABLE II. COMPLETE DATA AND RESULTS OF THE 20,000-KW. TURBINE TESTS AT MOORES PARK STATION

	Test No.	1	2	3	4	5	6
2.	Date of Test	11-6-27	11-7-27	11-7-27	11-8-27	11-8-27	11-8-27
3.	Time of beginning,	3-30 PM	9-15 PM	1-15 PM	8-45 AM	1-00 PM	9-00 AM
4.	Duration,	30	120	120	120	120	120
5.	Average Load on Unit, Net Kw.	5140	10388	15421	18034	20176	24167
6.	Temperature-Turbine Room, °F						
7.	Barometer, In. Hg.	29.24	29.39	29.36	29.30	29.26	29.25
8.	Steam Pressures:						
9.	At throttle, Lbs. Gage	262.5	262.3	262.1	261.1	260.3	255.3
10.	Inlet lbs. Abs.	89.0	157.0	226.7	262.1	266.4	258.1
11.	Secondary Valve, lbs. Abs.	49.1	87.0	126.1	145.9	169.6	215.0
12.	Nozzle No. 4 lbs. Abs.	37.4	66.4	96.4	112.1	127.8	163.6
13.	Nozzle No. 3 lbs. Abs.		24.5	36.2	42.4	49.4	64.2
14.	Nozzle No. 2 lbs. Abs.	6.0	9.6	13.0	16.2	18.1	23.2
15.	Nozzle No. 1 lbs. Abs.	1.3	2.3	3.2	3.7	4.7	5.8
16.	Exhaust, In. Hg.	.51	.54	.62	.66	.71	1.13
17.	Steam Temperatures						
18.	Throttle °F	576	595.4	585.3	576.6	581.8	599.0
19.	Superheat at throttle °F	166	185.4	175.1	166.6	172.1	191.0
20.	at Exhaust, °F	59.5	61.0	64.8	66.4	68.8	83.1
21.	Condensate						
22.	As weighed, lbs.per hr.		115138	163277	192318	217150	
23.	Corrected weight, lbs.per hr.		114678	162622	191548	216280	
24.	External Leakage, lbs.per hr.		560	622	640	870	
25.	Total, lbs.per hr.		115238	163244	192188	216920	
26.	Steam to Rado jet. lbs. per hr.		900	900	900	900	
27.	Condenser Leakage, lbs.per hr.		0	0	0	0	
28.	Net Condensate lbs.per hr.		114338	162344	191288	216020	
29.	Extraction to H.P.heater, lbs.per hr.		5000	5960	6100	8120	
30.	Net steam to Turbine,lbs. per hr.		119338	168304	197388	224140	
31.	Total Heat at Throttle, B.t.u. per lb.	1300	1312	1304	1300	1302	1313
32.	Heat of Liquid Feedwater leaving I P.Htr., B.t.u.		148.7	165.5	171.3	173.7	174
33.	Temp.Rise on H.P.Heater °F		44.7	37.2	32.1	38.6	20.9
34.	Total Heat of Liq.above 38°F.feedwater B.t.u.lb.		193.4	202.7	209.4	212.3	194.9
35.	Heat Supplied by Boiler, B.t.u. lb.		1118.6	1101.3	1096.6	1090.2	1117.1
36.	Heat Cons. per net kw.Hr.B.t.u./kw. hr.		12870	12030	11980	12120	
37.	Corrections: For superheat %		- .65	- 1.40	- 2.35	- 1.70	
38.	Steam Pressure %		+ .10	+ .10	+ .20	+ .35	
39.	Vacuum %		+.90	+ .20	+ .20	.0	
40.	Temp.Rise L.P.Heater %		-1.35	- 1.10	- 1.20	- 1.30	
41.	Temp.Rise I.P.Heater %		0	+ .80	.0	+ .80	
42.	Temp.Rise H.P.Heater %		0	0	0	0	
43.	Total Corrections %		-1.11	- 2.00	- 3.24	- 2.45	
44.	Heat Cons. Contr. Cond., B.t.u. Kw.-Hr.		12730	11789	11592	11823	
45.	Heat Cons. as Guaranteed B.t.u. per kw.hr.		13420	12520	12350	12460	
46.	Margin Better than Guaranteed %		5.15	5.8	6.15	5.15	
47.	High Pres.Heater						
48.	Stm.pres. at nozzle, Lbs. Abs.	37.4	66.4	96.4	112.1	127.8	163.6
49.	Stm.temp. in Extr. Line °F	407	411.7	412.3	413.4	467.9	519.0
50.	Total Heat at Heater, B.t.u. per lb.		1236	1233	1231	1256	1279
51.	Steam Pres. at Heater, lbs. Abs.		25	30	32	35	35
52.	Heat of Liq.in Drain, B.t.u. per lb.		208	219	222	227	227
53.	Heat Avail. for Htg.feedwater B.t.u./lb.		1028	1014	1009	1029	1052
54.	Total feedwater thru heater, lbs. per hr.		114678	162622	191548	216280	
55.	Feed water temp. - out °F	234	219.6	226.5	228.6	235.5	225.9
56.	Feed water temp. - in, °F		174.9	189.3	196.5	196.9	205
57.	Temp. Rise, °F		44.7	37.2	32.1	38.6	20.9
58.	Quantity steam extracted, lbs. per hr.		5000	5960	6100	8120	
59.	Intermediate Pressure Heater						
60.	Steam Pressure at Nozzle lbs.Abs.	6.0	9.0	13.0	16.2	18.1	23.2
61.	Steam Temp. at nozzle °F	170	193	206	217	223	236
62.	Total Heat at Heater B.t.u. per lb.	1130	1129	1126	1128	1139	1154
63.	Steam Temp. at Heater °F	156.5	181.1	198.7	204.6	206.4	208.5
64.	Steam Pres. at Heater lbs.Abs.	4.3	7.7	11.2	12.7	13.2	13.7
65.	Temp Drop (Nozzle to Heater) °F	13.5	11.9	7.3	12.4	16.6	27.5
66.	Temp. of Drain °F	161	175.2	187.0	190.9	193.2	195
67.	Heat of Liquid of Drain, B.t.u. per lb.	130	143	154.9	158.8	161.2	163
68.	Heat Avail.for heating feedwater B.t.u.per lb.	1010	986	971.1	969.2	977.8	991
69.	Total feed water thru heater, lbs.per hr.		114678	162622	191548	216280	
70.	Feed water Temp. out °F	158	180.7	197.5	205.3	205.7	206
71.	Feed water temp. In °F	105	114.7	127.3	131.1	138.4	150
72.	Feed Water temp. Rise °F	50	66	70.2	72.2	67.3	56
73.	Heat Absorbed by feedwater,Mill.B.t.u.per hr.		7.56	11.42	13.82	14.57	
74.	Quantity Steam Extracted lbs. per hr.		7680	11750	14280	14900	
75.	Low Pressure Heater						
76.	Steam Pressure at Nozzle, lbs. abs.	1.3	2.3	3.21	3.7	4.7	5.8
77.	Steam temp.at nozzle °F	111	122	144.5	150	159	169
78.	Total Heat at Heater B.t.u. per lb.	1053	1053	1051	1051	1062	1079
79.	Steam Temp. at Heater °F	104.5	116	126.8	134.1	142.9	155
80.	Steam Pres. at Heater lbs. abs.	1.07	1.5	2.27	2.47	3.11	4.2
81.	Temp.Drop (Nozzle to Heater) °F	6.5	16.0	13.7	15.9	16.1	14
82.	Temp. of Drain °F	104	116.8	131	134	142	153
83.	Heat of Liquid of Drain B.t.u. per lb.	72	84.7	98.9	101.9	110.1	121
84.	Heat available for htg.feedwater,B.t.u./lb.	981	968.3	952.1	949.1	951.9	958
85.	Total Feed water thru htr. lbs. per hr.		104388	145072	169818	191400	
86.	Feed water temp. out °F	105	114.7	127.3	131.1	138.4	150

	Test No.	1	2	3	4	5	6
88.	Low Pressure Heater (Contd.)						
89.	Feed water temp. in °F	89	85.6	83.8	83.5	83.8	96.4
90.	Feed water temp. rise °F	16	29.1	43.5	47.6	54.6	53.6
91.	Heat absorbed by feedwater,Mill.B.t.u./hr.		3.03	6.32	8.08	10.43	
92.	Heat flashed from low Pres.Htr.Mill.B.t.u./hr.		.50	.80	1.01	.95	
93.	Net Ht.Sup.by Extr. Steam, Mill,B.t.u./hr.		2.53	5.52	7.07	9.48	
94.	Rado-Jet (Air Pump)						
95.	Steam Pressure, lbs. abs.	159.4	158.4	158.4	159.9	160.4	179
96.	Steam Temp.at Jet (from tables) °F						
97.	Total Heat, jet, B.t.u. per lb.	1300	1312	1304	1300	1302	1313
98.	Back Pres.at Cooler, lbs. abs.	15	15	15	15	15	15
99.	Heat of Liq.at Drain, B.t.u. per lb.	180	180	180	180	180	180
100.	Heat avail. for htg.feedwater,B.t.u./lb.	1120	1132	1124	1120	1122	1133
101.	Total feedwater thru cooler,lbs. per hr.		104948	145694	170458	192040	
102.	Feedwater Temp. Out °F	89	85.6	83.8	83.5	83.8	96.4
103.	Feed water Temp. In °F	85.5	77	77.3	77.8	78.8	92.0
104.	Feed water Temp. Rise °F	3.5	8.6	6.5	5.7	5.0	4.4
105.	Heat Abs.by feedwater,Mill,B.t.u./hr.		.903	.948	.972	.96	
106.	Steam thru jets(computed) lbs.per hr.		798	840	870	860	
107.	Air Cooler						
108.	Feed water Temp. Out, °F	85.5	77.0	77.3	77.8	78.8	92.0
109.	Feed water temp. In. °F	60.0	62.1	66.3	67.8	70.1	85.6
110.	Feed water temp. Rise °F	25.5	14.9	11.0	10.0	8.7	6.4
111.	Quantity of feedwater thru cooler,lbs.perhr.		104948	145694	170458	192040	
112.	Heat abs. by cooler,Mill B.t.u. per hr.		1.565	1.592	1.705	1.67	
113.	Equivalent Kw. Utilized, kw.		460	467	498	490	
114.	Generator						
115.	Load Measurements,Item 4,Basis Results						
116.	By watt hr.meter (Disc.Rev.) kw.	5140	10388	15421	18034	20176	24169
117.	By Integrating Dial Readings,Check Kw.	5400	10580	15500	18200	20350	
118.	By Indicating Watt.Meter, Check kw.	5075		15380	18054	20446	24542
119.	Power Factor,(Calculated) %	79.8		81.7	83.4	85.7	98.0
120.	Generator Voltage, Volts.	12950		13000	13000	13000	13000
121.	Current per phase,						
122.	A. Amp.	288.4		839.2	961.6	1047.7	1095
123.	B. Amp.	287.5		842.2	964.4	1041.4	1095
124.	C. Amp.	287.5		835.7	963.7	1045	1095
125.	Average, Amp.	287.8		839.0	963.2	1044.7	1095
126.	Generator field						
127.	Amperes, Amp.	178.7		262.0	279.2	287	245
128.	Volts Volts	114.2		161.8	177.6	183.2	158
129.	k.w. Input Kw.	20.4		42.4	49.6	52.6	38.7
130.	Generator Exciter						
131.	Amperes Amp.	178.7		260	279.2	287	250
132.	Volts Volts	160.0		204	221.3	210.7	192
133.	Kw. Output kw.	28.6		53.0	61.8	60.5	48.0
134.	Generator Air Cooling						
135.	Temp. Out °C	48	45	47	48	50	51
136.	Temp. In. °C	30	28	29	30	30	32
137.	Temp. Rise °C	18	17	18	18	18	19
138.	Heat Absorbed by Air cooler,Mill,B.t.u.per hr.		1.565	1.592	1.705	1.67	
139.	* Volume of air (Computed) cu.ftper min.		47700	46000	49200	48200	
140.	Generator Stator winding temp. °C	60	55	62	66	70	76
141.	(measured by Temp.coils)						
142.	Condenser,						
143.	26000 sq.ft.cooling surface 1"O.D.tubes						
144.	No.16,Gauge 21'3" Long						
145.	Average Load on Unit Net Kw.	5140	10388	15421	18034	20176	24169
146.	Barometer, In Hg.	29.24	29.39	29.36	29.30	29.26	29.25
147.	Vacuum,						
148.	At Exhaust Nozzle, In Hg.	.51	.54	.62	.66	.71	1.13
149.	At Hot Well, In Hg.	.52	.56	.65	.69	.74	1.23
150.	Exhaust Steam Temp. °F	59.5	61.0	64.8	66.4	68.8	83.1
151.	Condensate Steam Temp. °F	60.0	62.1	66.3	67.8	70.1	85.6
152.	Circulating water Temp.						
153.	Out °F	48.5	52.2	56.0	56.0	58.0	74.3
154.	In °F	43.0	44.0	44.5	43.0	43.0	55.5
155.	Rise °F	5.5	8.2	11.5	13.0	15.0	19.3
156.	Terminal Difference °F	11.0	8.8	8.8	10.4	10.8	8.3
157.	Heat Content Stm.Boiler Side Throttle,B.t.u/lb	1300	1312	1304	1300	1302	1312
158.	Work done thru Expansion B.t.u. per lb.		328.6	344.6	348.6	343.6	338.1
159.	Heat Content at Ex.(Cond.Inlet) B.t.u. per lb		983.4	959.4	951.4	958.4	973.9
160.	Heat of Liq. in Condensate, B.t.u. per lb.		30.1	34.3	35.8	38.1	53.6
161.	Latent Heat of Steam (xr). B.t.u. per lb.		953.3	925.1	915.6	920.3	920.3
162.	Total Wt.Condensate to Cond. lbs.per hr.		103488	144172	168918	190500	
163.	Total Heat Rejected to Cond.Mill B.t.u.per hr		98.50	133.50	154.8	175.5	
164.	Mean temp.difference (logE) °F		12.42	15.7	16.05	17.25	
165.							
166.	Rate of Heat Transf.B.t.u. per sq.ft.per hr.		305	374	370	390	
167.							
168.	Circulating water, Gal. per min.		24000	23200	23800	22400	
169.	Velocity of Water thru Tubes,Ft.per sec.		4.86	5.15	5.03	4.9	

*Note: Q equals heat energy in B.t.u. required to increase temp. of V cubic ft. t deg. F. from 70 deg. F.

Q Vt 56. Ref. Hudson's Manual, p. 180

TABLE III. COMPLETE DATA AND RESULTS OF THE 1500-KW. TURBINE TESTS

TABLE III. COMPLETE DATA AND RESULTS OF THE 1500-KW. TURBINE TESTS

	Test No.,	1	2	3	4	5	6
1.		12-2-27	12-2-27	12-2-27	12-2-27	12-2-27	12-2-27
2.	Date of Test,	4-45 P	1-30 P	8-45 A	11-15 A	3-15 P	4-30 P
3.	Time of beginning,	60	60	120	60	60	10
4.	Duration, Min.	1/3	1/2	3/4	R.E	Full	100% P.F.
5.	Nominal Load on Unit,						
6.							
7.	Temperature of Turbine Room, °F						
8.							
9.	Barometer, In.Hg	29.21	29.17	29.14	29.14	29.17	29.17
10.							
11.	Steam Pressure,						
12.	At Throttle, Lbs.Gage	264.8	267.2	263.7	265.9	267.3	264.5
13.	Inlet, Lbs.Abs.	129.0	130.2	230.7	269.9	279.5	267.7
14.	Low Pres.Extr.Nozzle, Lbs.Abs.	2.61	3.56	4.48	5.07		6.69
15.	Exhaust In.Hg Lb.	.44	.45	.47	.47	.49	.50
16.	Rado Jet, Lbs.Gage	133	134	135	135	133	133
17.							
18.	Steam Temperatures,						
19.	At Throttle, °F	542.9	542.7	552.5	549.8	552.1	550.0
20.	Exhaust °F	55.5	56.0	57.0	57.0	58.0	59.0
21.	Superheat at throttle, °F	101.9	101.7	141.5	135.8	141.1	142.0
22.							
23.	Load,						
24.	Watt Meter Disc. No Rev.per hr	321	484	648.5	770	940	
25.	Meter Constant,	1600	1600	1600	1600	1600	
26.	Kw. Load by Watt Hr.Meter, Kw.	513	774	1037	1232	1504	
27.	Kw. Load, corrected, Kw.	512.6	772.5	1036	1231.5	1504	
28.							
29.	Steam Measurements,						
30.	A Quantity Water Weighed Lbs.per Hr.	3885	11695	14475	16625	19965	
31.	B Quantity Water,Corrected,Lb.per Hr.	8849	11647	14416	16558	19885	
32.	C Seal Water, Lbs.per Hr.	1496	1436	1446	1481	1401	
33.	D External Leakage, Lbs.per Hr.	42	48	71	53	37	
34.	E Steam to Rado Jet, Lbs.per Hr.	300	300	300	300	300	
35.							

	Test No.,	1	2	3	4	5	6
36.							
37.	Steam Cons. B-(C D-E) Act, Lbs. per Hr.	7095	9959	12741	14930	18221	
38.							
39.	Corrections.						
40.	For Steam Pres., %	0.15	0.15	0.15	0.15	1.0	
41.	Superheat,	-6.20	-6.20	-6.30	-6.00	-4.50	
42.	Vacuum	1.10	1.10	1.10	0.75	0.55	
43.	Total Correction	-4.95	-4.95	-4.05	-5.10	-2.95	
44.							
45.	Steam Cons.Cor.Constr.Cond. Lbs. per Hr.	6744	9466	12225	14074	17683	
46.							
47.	Engine or Rankine Cycle Eff. Ratio	.600	.645	.670	.691	.670	
48.							
49.	Steam Consumption of Unit,						
50.	Constr.Conditions, Lbs. per Kw.Hr.	13.15	12.23	11.78	11.41	11.75	
51.	Guar.(from Curve),Lbs. per kw.Hr.		13.35	12.41	12.02	12.42	
52.							
53.	Margin better than Guaranteed, %		8.4	5.1	5.1	5.4	
54.							
55.	Condenser Performance (3200 sq.ft.)						
56.	Circulating Water, °F	41.8	43.4	45.5	46.0	47.2	49.0
57.	Temp. Out, °F	37.9	38.0	38.8	38.2	38.0	38.0
58.	Temp. In, °F	3.9	5.4	6.7	7.8	9.2	11.0
59.	Rise,						
60.	Circulating Water, Gal. per Min.	3500	3540	3680	3660	3800	
61.	Terminal Difference °F	13.7	12.6	11.5	11.0	10.8	
62.	Mean Temp.Diff. (1100E) °F	8.0	10.9	13.2	15.2	17.6	
63.	Rate of Heat Trans.B.t.u.(sq.ft.)Hr.	264	272	286	287	306	
64.							
65.	Aver.Vel. of Water thru tubes,Ft.per Sec.	4.8	4.9	5.0	5.0	5.2	
66.	Condensate Temp °F	55	56	58	58	59	
67.							
68.	Ht.Cont.St.at Throttle,B.t.u. per lb.	1283	1283	1288	1284	1284	
69.							
70.	Ht.Cont.Ex. to Cond.,B.t.u. per lb.	989	985	981	976	981	

pumped through the high pressure heater to the boiler by a boiler feed pump, thus water passing through the heater was actually weighed.

Steam Flow to Turbine Determined by Weight

Heat content of the extracted steam into this high pressure heater was easily determined from pressure and temperature measurement as the quality was in the superheat region. It is quite evident that in the above described method the measurement, in the condensate form, of the total steam supplied to the turbine is accurately determined by calibrated scales. All pressure measurements of the steam were made by carefully calibrated test gages; the temperature measurements were made with certified thermometers and the vacuum in the condenser was determined as the average at four points of the turbine exhaust nozzle, 18 in. above the horizontal joints of the turbine and condenser.

Determination of the weight of steam extracted into the intermediate and low pressure heaters does not enter

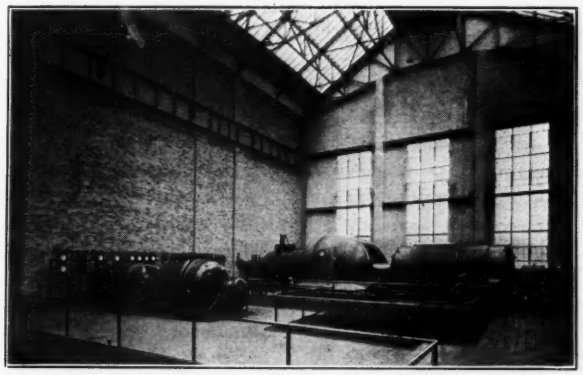


FIG. 15. THE NEW 20,000-KW. TURBO GENERATOR AND THE 1500-KW. AUXILIARY UNIT OF THE MOORES PARK STATION

directly into the calculation of the heat consumption of the unit when this extraction steam is weighed. However, computation results are set forth in the complete tabulated data in Table II.

Calculations were based on the temperature rise of a known amount of feedwater through the heater, thus obtaining the heat absorbed by the feedwater. The heat carried into the heater by the extraction steam must necessarily be equal to this quantity if radiation losses are neglected. The heat available for each pound of extraction steam was based on a definite heat content entering, minus the heat of the liquid as drained from this heater. The heat content of the steam was determined from the expansion line drawn and based on the heat economy of the turbine. These lines are shown in an entropy diagram, Fig. 13, the small circles in the expansion line representing the heat content and quality of the steam and the different extraction nozzles. The heat of the liquid as it drained from each heater was taken from the steam tables corresponding to thermometer readings at these points. Calculations for the high pressure heater and the quantity of extracted steam were based entirely on instrument readings. The heat

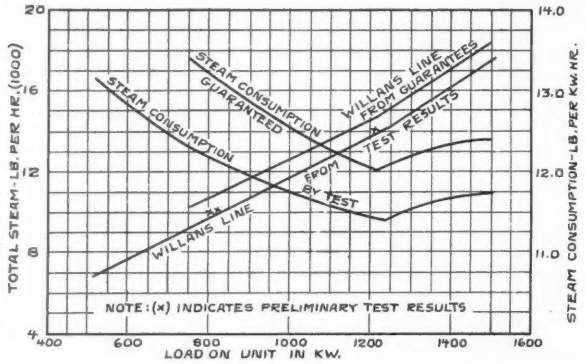


FIG. 16. COMPARISON OF THE TEST AND GUARANTEED STEAM CONSUMPTION OF THE 1500-KW. AUXILIARY TURBINE

content of the extracted steam was actually determined by thermometer and pressure readings.

An end view of the condenser is shown in Fig. 14. The circulating water temperatures, temperature differences and heat transfer values are given in Table II. Water velocities through the tubes averaged about 5 ft. per sec.

1500-Kw. Auxiliary Turbine Tested at Six Points

In the same general manner and with the same condensate water weighing equipment, the 1500-kw. unit mentioned previously and shown in the foreground of Fig. 15 was tested at six different load points. This unit is designed to operate as an independent prime mover to deliver electrical energy direct to the distribution system of the city, to the 4400-v. station bus or, when necessary, to serve the alternating current station motors through the house transformer 440-v. bus.

It consists of a 1500-kw., 80 per cent power factor, 4400-v., 3-phase, 60-cycle turbo-generator unit operating at 3600 r.p.m. It is designed to operate under a steam pressure of 250 lb. gage, 200 deg. F. superheat and 29 in. referred vacuum. The unit is straight condensing, the condenser being of the two-pass type with 3200 sq. ft. of cooling surface, made up of ¾-in. o.d., No. 18 B.w.g. Muntz tubes 12 ft. 2 in. long. Two Radojet air pumps and two 2-in. condensate pumps with a capacity of 75 g.p.m. against a head of 75 ft., direct connected to 7.5 hp., 1800-r.p.m. motors, are provided. Circulating water is supplied by one 4000-g.p.m. motor-driven pump, the discharge from the condenser being so connected that circulating water may be delivered either to the river or returned to the intake in order to provide means for recirculation when necessary.

This generator is also equipped with a closed generator air cooler located directly beneath the generator and equipped with connections so that either condensate or river water may be used. Steam consumptions of the unit were determined at four separate loads, and complete results of the tests are given in Table III.

These figures do not include steam or power used by accessories or auxiliaries, but are the true electrical outputs of the generator terminals and include energy required in the field for excitation and the steam required to drive the direct connected exciter. Steam consumption results are set forth graphically in Fig. 16, which also shows Willan's Line for both the test results and guarantees. The Rankine cycle efficiency ratio of the unit is shown in Fig. 17.

Comparative heat consumption for both the 20,000-kw. unit No. 3 and the 1500-kw. auxiliary unit with that of the two older units, No. 1 and No. 2 is illustrated graphically in Fig. 18. This shows the steady progress made in increasing the economy and efficiency of the prime mover in the generation of electrical energy. It will be noted on this chart that at the most economical

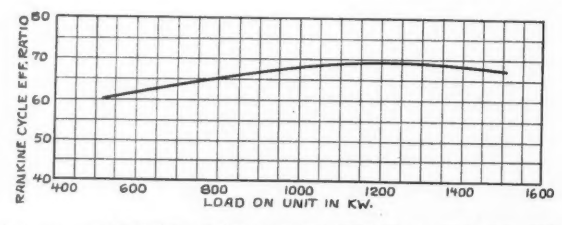


FIG. 17. RANKINE CYCLE EFFICIENCY RATIO OF THE 1500-KW. TURBINE

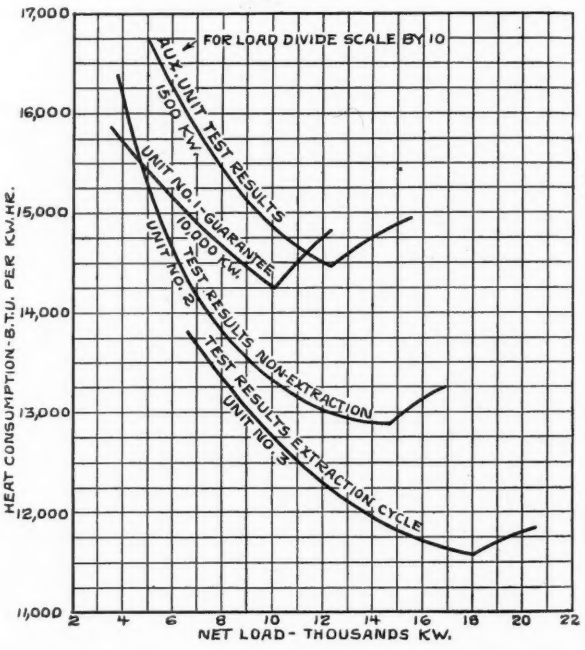

FOR LOAD DIVIDE SCALE BY 10
AUX. UNIT TEST RESULTS 1500 KW.
UNIT NO. 1 - GUARANTEE 10,000 KW.
UNIT NO. 2 TEST RESULTS NON-EXTRACTION
TEST RESULTS EXTRACTION CYCLE UNIT NO. 3
HEAT CONSUMPTION - B.T.U. PER KW. HR.
NET LOAD - THOUSANDS KW.

FIG. 18. COMPARISON OF THE TEST RESULTS OF FOUR TURBINES IN THE MOORES PARK STATION

point of both units the heat consumption of the 1500-kw. unit is only 250 B.t.u. per kw-hr. more than that for the 10,000-kw. unit.

Gains in economy are likewise striking in the best performance of the 20,000-kw. unit compared to that of the 15,000-kw. unit, which amounts to 1300 B.t.u., or over 10 per cent improvement. The most economical load point and the heat consumption of the 20,000-kw. unit of 11,600 B.t.u. per kw-hr. represents 83 per cent of the heating value of 1 lb. of 14,000 B.t.u. coal. The 1500-kw. unit should also give a good account of itself as a prime mover at light load and for special service, as well as for the intended service of generating power for the alternating current station auxiliaries.

Operating Experiences with 1300-lb. Pressure

SUMMARY OF THE OPERATING EXPERIENCES AND DIFFICULTIES ENCOUNTERED DURING A PERIOD OF ELEVEN MONTHS AT THE LAKESIDE STATION. BY JOHN ANDERSON*

THOUGH THE HIGH PRESSURE installation at Lakeside Station has been in service 57 per cent of the 11 months period since starting, operating one continuous period at full capacity (approximately 300 per cent boiler rating) for 50 days, and improving overall plant efficiency 4 per cent, major troubles have been experienced. The desirability of 1300-lb. steam pressure is certain, and widespread adoption will occur in the near future. It is felt important that detailed information on operating experiences be widely disseminated, for the power industry is so large and is growing so rapidly, that the interchange of information nets great economic savings.

For purposes of discussion this 11-month period of which Table I is the service record, can be divided into three parts, discussing:

1. Experiences with tube failures from scale formation.
2. Boiler tube corrosion troubles.
3. Chemical control of feedwater and resulting correction of trouble.

SCALE FORMATION DIFFICULTIES

Higher stresses in the 1300-lb. boiler tubes and higher temperature of boiler water prompted the decision to feed this high pressure boiler with only evaporated makeup from the 300-lb. boilers, even though no scale troubles have been experienced with the 300-lb. boilers in their 6 yr. of operation without evaporators. Because of the characteristics of the lake water used for makeup, the 300-lb. boiler would operate 5000 hr. and upon cleaning contain less than 50 lb. of scale with a maximum thickness of $\frac{1}{16}$ in.

On the high pressure boiler the first suggestion of tube trouble occurred after 880 hr. of operation, when a hissing noise was heard in the furnace, suggesting a small steam or water leak. An inspection showed that a front wall fin tube near the east wall had bulged near its upper extremity, presumably where highest heat transfer occurred due to nearness to the burner tips.

Cutting of the tube into cross sections showed that it was coated quite uniformly with $\frac{1}{32}$ in. scale over the side exposed to the furnace, except at the bulge, where scale filled nearly the entire extruded section. Whether the $\frac{1}{32}$ in. of scale caused the bulge, or whether greater thickness had collected previous to the failure could not be deduced.

Like others later experienced, the bulge was about $1\frac{1}{2}$ in. in diameter and $\frac{1}{2}$ in. high. Probably 50 similar bulges were observed during later experiences with scale trouble, and though some were almost adjacent over lengths of several feet on a single tube, no splitting of the tube with consequent explosive rupture occurred. Operation over two weeks with this kind of leakage has proved that high pressure operation is entirely safe.

Apparently a small hole at the tip of the bulge, less than $\frac{1}{16}$ in. in diameter, affords sufficient circulation to prevent further blistering. Moisture measurements in the flue gas by determination of dew point has on many occasions shown that about 0.5 per cent of the boiler output is lost by one opening. The maximum leakage occurring at any one time was 2.2 per cent. Analysis of the scale near failures showed it to be much like that in other boilers, consisting of soft, non-scale-forming materials cemented to the tube by hard scale-forming materials.

Other fin tubes near the one that failed were bowed away from the furnace slightly, suggesting that the

TABLE I. OPERATING PERIODS OF THE LAKESIDE HIGH PRESSURE BOILER

Period No.	Date, Start & Finish	Boiler		Turbine		Boiler Stoppage	
		Hours	Output Mill. lb	Hours	Mill. k w Output	Hours	For
1	10-25-26 11-18-26	541·75	84·166	381·75	2·143	288	Burner Change
2	12-1-26 12-11-26	239·5	40·05	200·98	·947	216	One fin tube failure due to scale
3	12-20-26 1-20-27	726·25	152·36	702·37	3·985	192	Ten fin tubes replaced due to scale
4	1-28-27 3-10-27	1.195·75	289·1	1.178·02	7·526	360	Ten fin tubes and 28 boiler tubes replaced due to scale
5	4-3-27 4-19-27	391·75	73·79	352·02	1·900	1.008	Air heater change Tubes all right
6	5-11-27 6-3-27	86·25	15·90	73·13	·462	312	One arch tube replaced due to burner misadjustment
7	6-16-27 6-21-27	142·75	23·04	111·05	·744	168	Four boiler tubes replaced due to corrosion
8	6-28-27 7-1-27	92·25	16·98	85·53	585	144	Inspection, turbined two front rows tubes
9	7-7-27 7-13-27	131·5	28·12	126·75	·737	384	Turbined all tubes Replaced three fin and seven boiler tubes due to corrosion
10	7-29-27 8-5-27	167·25	32·06	87·43	460	168	Inspection, tubes turbined O K
11	8-12-27 9-3-27	514·75	117·5	191·23	1·075	216	Inspection O K
12	9-12-27 9-29-27	419·5	102·31	303·42	2·614	120	Inspection O K
	TOTAL	4.649·25	985·366	3.883·68	23·187	3.576	

troubles were not isolated to the one tube. All tubes were turbined and 25 lb. of boiler compound, containing about 2/3 soda ash, was inserted in the boiler drums before the next run.

How solids got into the boiler water was a matter of question, and was not determined until a test of the high pressure turbine with the high pressure boiler isolated from the remainder of the station showed about 2 per cent condenser leakage into the feedwater. Adjustment of the tube packing was immediately commenced, but no marked success was attained until the condenser was entirely repacked.

SCALING TROUBLES CHANGED TO CORROSION AFTER THE CONDENSER LEAKAGE WAS REDUCED

After 720 hr. operation on period No. 2, making 1600 hr. total since new, 10 more fin tubes had to be replaced because of blisters or excessive bowing. At first the trouble was confined to tubes near the side walls, presumably because of air shortage still occurring at that point even though deflectors were installed to improve the air distribution. Improvements in the baffling of the front wall were made until the air flow was positively uniform across the furnace width.

During the same stoppage 28 boiler tubes had to be removed because of blisters or warping. The blisters

*Vice-President in Charge of Power, The Milwaukee Electric Railway & Light Co., Milwaukee, Wis. Abstract of a paper presented before the Institute of Fuel, London.

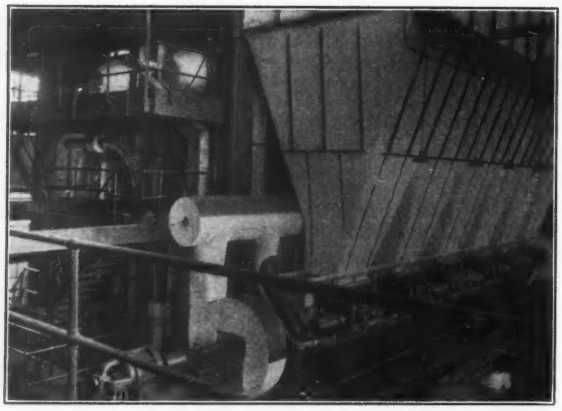


FIG. 1. VIEW OF THE LAKESIDE HIGH PRESSURE BOILER

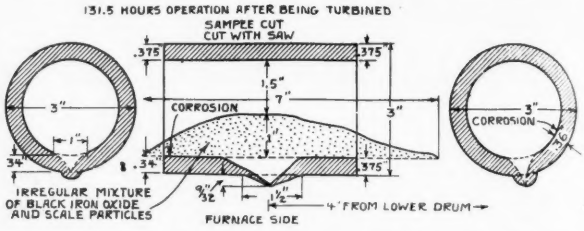


FIG. 2. BOILER TUBE FAILURE DUE TO ACTIVE CORROSION

occurred opposite the top of the first pass baffle, at a point where the sum of the heat transfers by convection and by radiation is a maximum. To equalize the severity of service throughout the length of the boiler tubes, the baffle was moved back two rows; the velocity of water circulation in the front row of boiler tubes was increased by installing bell mouth entrances and exits in the lower and upper drums; all tubes were turbined and the boiler put back into service, feeling that at least localized overheating would be diminished, but that possibly more failures would occur.

Explanation of the cause of failure by use of known data of heat transfer rates and metal strengths at long, sustained high temperatures was attempted, to learn if the high pressure service was imposing conditions requiring the use of better metal in tubes exposed to the furnace. Boiler tubes for this boiler are 3-in. o.d., low carbon steel, 0.35 in. thick, stressed at 4270 lb. per sq. in. The tensile strength is 58,000 lb. per sq. in., the yield point 46,000 lb. per sq. in. and an analysis shows 0.16, 0.43, 0.009, 0.036 per cent, respectively, of carbon, manganese, phosphorus and sulphur. Calculations covering a range of service conditions as regards heat transfer rates, velocity of water in tubes and thickness of scale, indicated that 900 deg. tube temperature would occur under actual operating conditions with scale of $\frac{1}{16}$ in. thickness. A sample of one of these calculations is shown in Table II, which if studied will show the effect of circulation through the tube and that of scale thickness in terms of temperature difference.

This table is based on the heat transfer rate of 46,500 B.t.u. per sq. ft., a value realized in actual practice and determined from the average transfer rate of the radiant heat superheaters and reheater. Conclusions of this analytical work are summarized by stating that a maximum scale thickness of $\frac{1}{32}$ in. can be tolerated, and that $\frac{1}{16}$ in. means a tube failure. This agrees with practice and reconciles test data with actual experience. It was felt necessary to turbine the boiler at least every 500 hr.

The next run of 390 hr. was made without a failure. The boiler was again turbined, and the next run came to an untimely end by failure of a riser tube underneath the arch due to high heat transfer by combined radiation and unusually high convection. It was felt that the scale situation had nothing to do with this failure, since inspection showed the tube clean and the nearby burner so out of adjustment that its flame impinged directly on the fin tube.

Corrosion Period

Later, failure of four boiler tubes only 330 hr. after being turbined, and with very low condenser leakage seemed to upset all previous deductions in regard to preventing scale troubles. It seemed impossible that less than 1/10 per cent condenser leakage would furnish enough solids to cause tube failure through scale formation. Continuous operation of the boiler would be impossible unless some sort of feedwater treatment could be used to prevent scale formation entirely.

Inspection of the blisters, Fig. 2, showed them to be of a different nature from those experienced previously. The bulge was more pointed, and had a diameter of only ¾ in. Moreover, the deposit inside the bulge was apparently of a different nature, being predominantly black in color and in greater quantities than before

TABLE II. TABULATION OF CALCULATIONS SHOWING THE EFFECT OF SCALE THICKNESS AND WATER VELOCITY ON TUBE TEMPERATURE

Heat Transfer Conditions.	Poorest			Best.			
Velocity of water in tube, ft. per sec. ...	1	2	4	6	8	10	12
Temp. drop through water film* Deg. F ...	175	100	58	42	33	27	24
Thickness of scale, inches	1/8	3/32	5/64	1/16	3/64	1/32	1/64
Temp. drop through scale	180	137	114	91	68	45	23
Temp. drop through metal	64	64	64	64	64	64	64
Total temp. drop between water and tube exterior	420	301	236	197	165	136	111
Temperature of water	575	575	575	575	575	575	575
Temp. of external tube metal	995	876	811	772	740	711	686
Assumed Maximum long-time strength ...	2,500	4,500	6,000	8,000	8,500	9,000	9,500
Actual Stress	4,300	4,300	4,300	4,300	4,300	4,300	4,300
Factor of Safety	.6	1.05	1.4	1.85	2.0	2.1	2.2

TABLE III. SUMMARY GIVING THE SIGNIFICANT DATA AND RESULTS OF EACH FEEDWATER TREATMENT PERIOD

Treatment Period No.	Boiler Water Concentration, P.P.M.					Treatment P.P.M.*	Hours in Service	Oxygen in Fd. Water cc/litre	Results		
	NaOH	Na_2CO_3	Na_3HPO_4	Na_2SO_4	Total** Solids				Corrosion	Scale	Minimum Turbine Capacity
1	185	34	46	0	265	6·23	131·5	·45	Yes	Yes	O.K.
2	138	35	171	437	781	6·08	167·25	·055	No	No	4,200
3	80·5	29	82	408	585	3·98	514·75	·03	No	No	6,500
4	52	8	40	283	383	2·35	419·5	·03	No	No	6,800

** Not including small amounts of Silica, Oxides, etc * Pounds of chemical per million pounds feed water.

experienced. Most of the substance was black iron oxide, obviously the product of an electrolytic corrosion process.

Water Treatment Periods

It was apparent that troubles had changed from scale to corrosion. Whereas previously solids in the raw water had formed a protective coating over the tubes, now localized corrosion occurred because of elimination of raw water make-up without an attendant care in conditioning boiler feedwater. The boiler manufacturer suggested treatment of feedwater and accordingly the next period of operation was started with tri-sodium phosphate introduced in such amounts that a caustic alkalinity of about 200 p.p.m. (parts per million). A phosphate concentration of about 50 p.p.m. was maintained. The following is an outline of four divisions of the treatment period, with Table III giving the treatment data in detail: Period No. 1. Desirable alkalinity but excess oxygen and deficit of phosphate. Period No. 2. Maintenance of 800 p.p.m. total solids and low oxygen. Turbine trouble from carry-over. Period No. 3. Maintenance of 600 p.p.m. total solids. Turbine trouble lessened. Period No. 4. Maintenance of 300 p.p.m.; turbine operation all right.

Before putting the boiler into service 50 lb. of tri-sodium phosphate, equivalent to 22 lb. of the dry salt, was inserted in the feedwater drum. A forced stoppage after 130 hr. operation when two leaks in the furnace developed demonstrated the absolute necessity of lowering the oxygen content below 0.45 c.c. per litre. Three fin tubes and seven boiler tubes had to be replaced because of excessive corrosion. In some cases deposits of such magnitude were built up in the tubes during this short time that it was impossible to see through a short length of tubing. Consideration of the problem showed that decrease of oxygen content to 1/10 c.c. per litre or lower was positively necessary. This was obtained by adequately steam sealing the V-notch meter and paying attention to the aeration of condensate at the condenser hotwell.

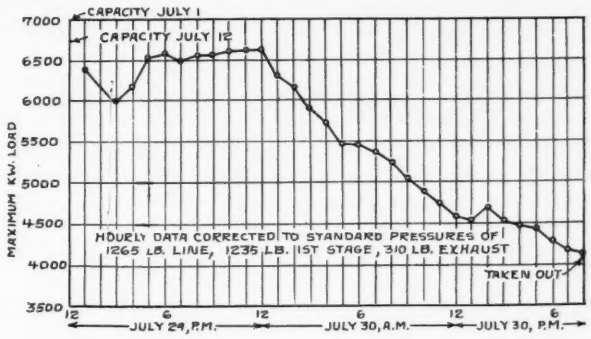


FIG. 3. REDUCTION IN GENERATOR OUTPUT DUE TO DEPOSIT ON BLADES

Immediately upon starting the second treatment period in which boiler water concentration was maintained at an average of 800 p.p.m. and a maximum of 1100 p.p.m. with additions to tri-sodium phosphate and sodium sulphate, a considerable decrease in capacity of the 1200 lb. high pressure turbine was noticed.

As shown by Fig. 3, in one and one-half days the maximum delivered output was decreased from 6600 kw. to 4200 kw. at a time when the boiler water concentration was highest. During this time the steam flow through the machine decreased only 10 per cent, indicating an efficiency decrease of almost 30 per cent.

Arrangements were made to inject about 10,000 lb. per hr. of water into 15,000 lb. per hr. of steam entering at the turbine throttle when the turbine was rotating at about 400 r.p.m. Upon again putting the machine into service it carried full load. Subsequent operation with loss of capacity required later washings and always the full capacity of the machine was regained.

On one occasion when the turbine could be removed from service without loss of station efficiency, inspection showed that the first ten stages of the machine were free from deposit, and the latter half of the unit totally

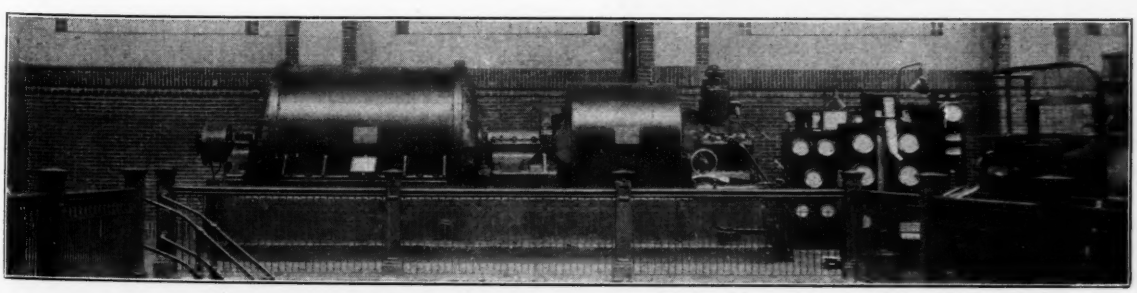


FIG. 4. THE 1200-LB. TURBO-GENERATOR UNIT AT LAKESIDE

covered with a white composite coating of high melting point elements cemented into a hydrate binder. Examinations made of the inside of the superheater elements corroborated observations at the turbine.

Obviously the determination of the amount of carry-over from the boiler was an important one at this time of turbine trouble and a method was devised whereby

TABLE IV. ANALYSIS OF SLUDGE TAKEN FROM THE LOWER DRUM AND SCALE TAKEN FROM NEAR A FAILURE

	Sludge, per cent	Scale, per cent
Iron oxide and alumina	24.26	15.24
Calcium hydrate	.....	33.63
Calcium carbonate	21.46	.....
Calcium silicate	.....	23.66
Calcium sulphate	.41	14.62
Magnesium hydrate	8.63	6.90
Magnesium carbonate	2.62	1.28
Magnesium silicate	38.31	.....
Magnesium sulphate	.39	.54
Magnesium oxide	4.23	.....
Copper oxide	.28	1.58
Lead oxide	.....	2.06

the moisture could be determined with an electrical conductivity apparatus. About 100 hr. of moisture readings at 2-min. intervals showed the boiler to be delivering about ⅓ per cent moisture, though at times a variation between 0.2 per cent and 0.5 per cent was noted. This percentage moisture was thought to be good practice for a boiler operating at 300 per cent rating and at 1300 lb. per sq. in. pressure.

Installation of baffles in the top drums and decrease of concentration of solids in the boiler water effected a decrease in carry-over to such a point that deposits on the turbine blading did not collect accumulatively. After washing, a slight decrease of capacity would be noticed in the first few days, then the efficiency would become stabilized and would not decrease any further. This is the condition under which the turbine is operated at present. It is carrying a load of 6800 kw. with a water rate of about 36 and an efficiency of approximately 73.5 per cent on the electrical output basis. It appears that the sodium hydrate can bind other solids to the blading to only a certain small maximum

TABLE V. ANALYSIS OF THE DEPOSIT FOUND NEAR A FAILURE DURING THE CORROSION PERIOD

	Per cent	Per cent
Silica	3.93	6.31
Loss on ignition	6.59	.....
Black iron oxide	53.30	71.99
Calcium oxide	24.00	.....
Aluminum oxide	12.00	7.06
Calcium hydrate	.....	8.06
Calcium sulphate	.....	1.22
Copper oxide	.....	1.24
Magnesium silicate	.....	4.15

thickness when boiler water concentration is low. Information that sodium phosphate has ten times the effect of sodium sulphate in inhibiting caustic embrittlement may allow discontinuance of treatment with sodium sulphate and thus so lower boiler water concentrations that no effect upon the turbine capacity will occur. Two inspections have recently been made after periods of operation of approximately 450 hr. each with less than 400 parts per million total solids, 700 p.p.m. of which was hydrate concentration and 60 p.p.m. phosphate.

Drilling of many tubes with no signs of corrosion and practically zero scale proved that the above low alkalinity and phosphate concentration are totally effective in preventing corrosion and scaling. It is believed that the presence of phosphate will so prevent scale formation that runs of indefinite length without stoppage can be made. On the basis of these last two inspections, it is expected that the boiler will never again be cleaned.

General Conclusions

Summation of conclusions derived from experiences as they occurred are as follows:

1. For high pressure service some means of providing nearly scale-free make-up, or some treatment of feedwater to prevent scale formation, is positively necessary in high pressure boilers operating at high ratings. Major reasons for this requirement are:

(a) 150 deg. higher water temperature than in 300-lb. boilers.

(b) Higher metal stresses equivalent to an additional 150 deg. higher tube temperature.

2. Maintenance of an appreciable caustic alkalinity and reduction of oxygen in feedwater to below 1/10 c.c. per litre is necessary to prevent corrosion in high pressure boilers fed with evaporated makeup.

3. Boiler behavior at 1300 lb. pressure is better than at 300 lb. pressure, water levels being very stable and moisture in the steam being desirably low.

4. The presence of sodium hydrate in boiler water may result in loss of efficiency over certain sections of turbine blading.

5. Boiler tubes in service have decreased in tensile strength and elastic limit to such an extent that the usual method of testing when new does not show their true strength after service.

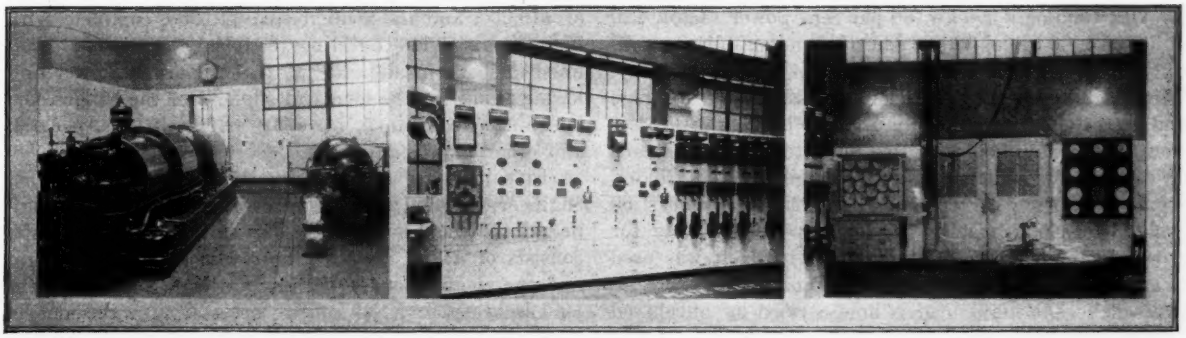
6. Use of tri-sodium phosphate in boiler water present in relatively small concentrations thoroughly inhibits formation of scale, although previous to such treatment scale was observed to form much quicker than in 300-lb. boilers.

Finally, it may be said that, though higher pressure puts more exacting requirements upon boiler materials,

TABLE VI. AN ANALYSIS OF THE WHITE DEPOSIT FOUND ON THE HIGH PRESSURE TURBINE BLADING

	Per cent
Silica	56.0
NaOH	23.8
Na_2CO_3	16.3
FeO	3.6

safe and continuous operation is positively possible. Desirable reaction to feed treatment is proved, and no conditions have occurred which were not corrected satisfactorily. There is every reason to believe at present that the unit can be kept in service as long as desired, and an order for an additional 1300-lb. equipment will soon be placed.



Industrial Plant Effects Marked Saving

PITTSBURGH PLATE GLASS CO.'S NEW $226,000 POWER PLANT SAVES $47,000 DURING FIRST YEAR'S OPERATION. EFFECTIVE USE OF INSTRUMENTS ASSURED BY INCORPORATING THEIR READINGS IN ACCOUNTING DEPARTMENT REPORT

CORRELATION of the industrial power plant with other departments is assuming increased importance as the standard of operation is raised from year to year by more efficient machinery and improved plant design. Unfortunately, however, a new plant, unless its operation is properly supervised and tied in with the remainder of the organization is not likely to develop its maximum value to the organization. Not only must instruments be provided to enable the operators to know what they are doing, but supervision should be arranged to see that the instruments are utilized.

At the Milwaukee plant of the Pittsburgh Plate Glass Co., problems of this kind have been effectively solved and a new $226,000 power plant erected in 1924 not only saved $46,829 during the first year's operation, but resulted in an improved condition throughout the plant by furnishing a steady and reliable source of power and process steam from a single source. In 1924 three boiler plants were operated, the total cost of steam and purchased power during the year amounting to $50,174. In 1925 steam was furnished from the new plant which replaced the other three, and although both the steam and power demands doubled, total cost dropped to $46,361, representing a saving of $46,829 based on the 1924 steam cost and purchased power at $0.015 per kw-hr., this price representing an allowance made for increased power consumption of 1925.

Although the cost of power has but a small effect on the unit cost of the output of a plant, taken as a total, $47,000 is an appreciable amount.

Both high and low pressure process steam and electric power are used in the plant, some of the power being generated in a back pressure turbine, some of it being purchased from the Milwaukee Electric Railway and Light Co. Steam at 175 lb. gage, 75 deg. superheat is furnished by three 350-hp. longitudinal drum Heine boilers, fired by Type E stokers. Two of these boilers are set in a battery as shown in Fig. 1, with the third boiler set singly. Space is provided in the boiler room for an additional unit should future steam demands justify its installation. The boilers are baffled horizontally, as shown in Fig. 2, the entire length of the lower rows of tubes being in the first pass, the superheater being located behind the bridge wall. Feedwater regulators, mechanical soot blowers and automatic damper regulators are used. Boiler auxiliaries, that is, the forced draft fan, driven by two steam engines, two 12 by 18 by 14 duplex boiler feed pumps, feedwater heater and a lime and soda water treater and filter are located at one end of the boiler room, as shown in Fig. 3.

Coal is received by truck, passed through a single roll crusher and, by means of an elevator and belt conveyors, stored in a 300-t. overhead bunker. From the bunker it is spouted directly to the stoker hoppers. Ash is handled by an 8-in. steam jet ash conveyor, delivering ashes to a 30-t. hopper. This hopper is emptied once a week. An 11 by 14 by 16-in. single vacuum pump is used on the heating system for condensate return and a 150 cu. ft. displacement, four-cylinder, single stage, single acting air compressor, driven by a 30-hp. motor is installed to provide air for air tools and general service throughout the plant.

BACK PRESSURE TURBINES FURNISH ELECTRIC POWER

The turbine room, shown in the three views in the headpiece, contains two turbo-generators, switchboard,

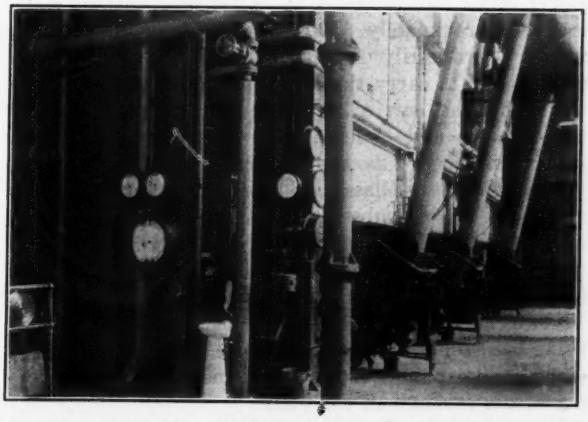


FIG. 1. BOILER ROOM OF THE PITTSBURGH PLATE GLASS CO. POWER PLANT AT MILWAUKEE, WIS.

filing cabinets and engineer's desk. The large machine, an Allis-Chalmers 500-kw. 80 per cent power factor, 220 v. 3-phase, 60-cycle, 3600-r.p.m machine supplies practically all the power used in the plant during the day. This machine operates at a back pressure of 5 lb. gage and the exhaust is ordinarily used for heating or process work. It is supplied with two air filter units, one unit on each intake. The smaller machine is an Allis-Chalmers 90-kw. 80 per cent power factor, 220 v., 3 phase, 60 cycle, 3600 r.p.m. machine and is now used mainly for power factor correction although originally it was used to carry the night load. In 1926 transformers were installed and the night load is now carried by purchased central station power.

During the period covered by the first power bill,

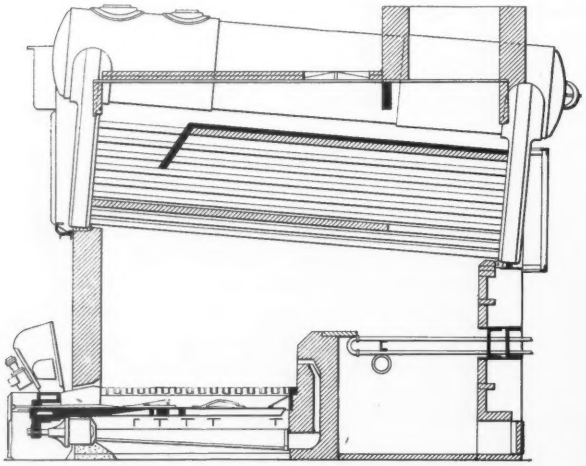


FIG. 2. LONGITUDINAL SECTION OF THE BOILER SETTING SHOWING METHOD OF BAFFLING AND LOCATION OF SUPERHEATER

the power factor averaged 62 per cent with 85-kw. demand based on a 15-min. peak. The 90-kw. unit was connected to the company's bus and to the power company's bus with interlocking switches so as to correct the power factor either way. The unit is brought up to speed with the turbine and synchronized after which the throttle is merely cracked in order to supply sufficient steam to cool the turbine. After the unit had been connected in this way and operated for about two weeks, the power factor had increased to 94 per cent, making a decrease approximately $100 on the power bill for the month. Ordinarily the large machine supplies sufficient power to carry the entire plant for the day, with the night load carried by the power company, so that the turbines and boilers can be shut down. The 11 panel switchboard is of Carrara glass, made by the Pittsburgh Plate Glass Co., principally for table tops and as a marble substitute. It is non-absorbent, has a high dielectric strength and cannot be stained, so that it makes a remarkably good switchboard, although too expensive for ordinary switchboard construction. Three generator panels are provided, one of them now being used for the incoming power company's line. The eight service panels are divided among the various departments throughout the plant.

Complete, the plant cost $226,000, which was divided $180,000 for the boiler plant and $46,000 for the turbine room. The turbo generators themselves represent a cost of $19,000, and the switchboard $10,000, complete with instruments. The building itself is exceptionally well finished, both inside and out with separate shower and locker rooms for the men and one end of the boiler room laid out with cabinets for spare parts, fittings, packing and other plant equipment.

Five men are on the operating crew, one 1st class engineer, one 2nd class engineer and one 3rd class engineer for firing comprise the day shift. The night shift consists of a 2nd class engineer who operates all night and one clean-up man. In the winter months when the load is heavy, it is, of course, necessary for the men to work their full 12-hr. shift seven days a week. During the summer months, however, when the boilers are banked at night, the work is divided among the men by the chief, and no attempt is made by the company to supervise the hours, it being assumed that the long steady shifts during the winter months is compensated for by the shorter shift and light work during the summer months when the spare time can be used by the men to advantage.

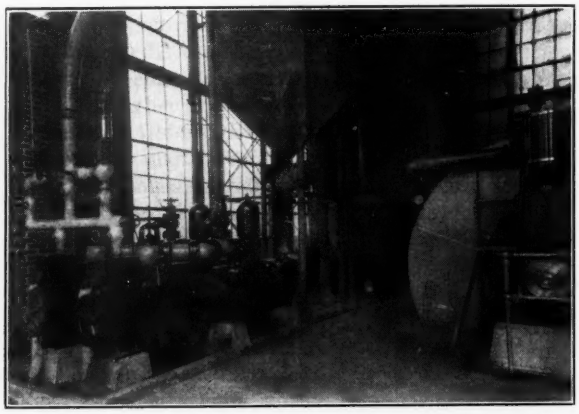


FIG. 3. BOILER FEED PUMPS, WATER SOFTENER AND FORCED DRAFT FANS LOCATED IN ONE CORNER OF THE BOILER ROOM

Recording watt-hour meter readings give the total power consumption and the total of this meter must, if the meters are correct, check the total of the individual meters the readings of which are recorded daily on report sheet A, Fig. 4. Boiler feedwater to all three boilers is metered by a mechanical flow meter, and the readings of this meter, minus blowdown and other losses should equal the sum of the three individual boiler steam flow meters. Actually they check within about 2 per cent, which is taken as a fair representation of the blowdown losses. From the boilers the steam may go to one of three lines, either to the high pressure process, through a reducing valve to the low pressure process or through the turbine. Ordinarily steam supplied to the turbine also goes to the low pressure process system, requirements beyond that supplied by the turbine being furnished through the reducing valve or any excess above the demand for the process going to the atmosphere.

Steam for the various departments is metered by electric flow meters of either the integrating or recording and integrating type with the records located in the

turbine room in a compact group visible to the engineer at his desk. Two high pressure and five low pressure distribution meters are used. Monthly charges for the various departments are computed upon the basis of the steam generated, the total cost of operating the boiler plant and the amount of steam used. No distinction is made in price between the high pressure and low pressure steam.

No charge is made to power for the steam used in the turbine provided it is afterwards used in the process system. The steam charge against the turbines or power system, therefore, depends upon the amount of steam blown to the atmosphere, that is, the difference between the sum of the three boiler steam meters and the sum of the seven distribution meters. This, of course, results in a proportionately high power cost during the summer months, when the demand for heating and process work is low, and low power cost during the winter months when practically all of the steam is used. Power charges to the various departments are not made on the kilowatt-hour basis, but the total cost of the power and light sections for the month is prorated between the different departments on the kilowatt-hour basis. This method of estimating is, of course, not absolutely accurate, as the power account absorbs all system losses. It is, however, thought to be satisfactory, inasmuch as the results are used only for inter-departmental charges, and it is not felt that the expense of instruments required to obtain an absolutely accurate estimate would be justified.

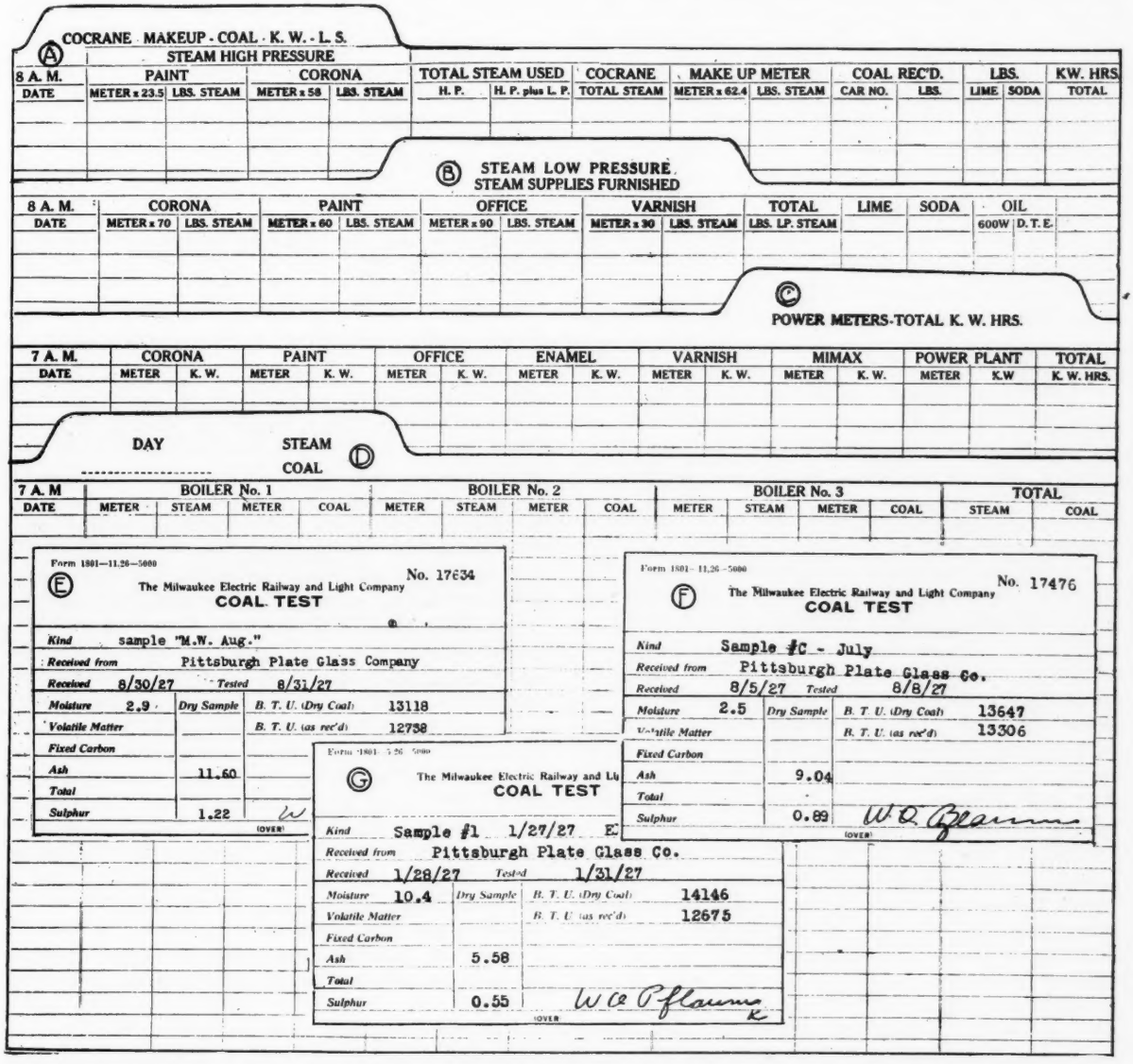

(A) COCRANE MAKEUP - COAL - K. W. - L. S.
STEAM HIGH PRESSURE
8 A. M. DATE | PAINT METER x 23.5 | PAINT LBS. STEAM | CORONA METER x 58 | CORONA LBS. STEAM | TOTAL STEAM USED H. P. | H. P. plus L. P. | COCRANE TOTAL STEAM | MAKE UP METER METER x 62.4 | MAKE UP METER LBS. STEAM | COAL REC'D. CAR NO. | COAL REC'D. LBS. | LBS. LIME | LBS. SODA | KW. HRS. TOTAL
(B) STEAM LOW PRESSURE
STEAM SUPPLIES FURNISHED
8 A. M. DATE | CORONA METER x 70 | CORONA LBS. STEAM | PAINT METER x 60 | PAINT LBS. STEAM | OFFICE METER x 90 | OFFICE LBS. STEAM | VARNISH METER x 30 | VARNISH LBS. STEAM | TOTAL LBS. LP. STEAM | LIME | SODA | OIL 600W | OIL D. T. E.
(C) POWER METERS-TOTAL K. W. HRS.
7 A. M. DATE | CORONA METER | CORONA K. W. | PAINT METER | PAINT K. W. | OFFICE METER | OFFICE K. W. | ENAMEL METER | ENAMEL K. W. | VARNISH METER | VARNISH K. W. | MIMAX METER | MIMAX K. W. | POWER PLANT METER | POWER PLANT K.W | TOTAL K. W. HRS.
DAY
STEAM
COAL
(D)
7 A. M. DATE | BOILER No. 1 METER | BOILER No. 1 STEAM | BOILER No. 1 METER | BOILER No. 1 COAL | BOILER No. 2 METER | BOILER No. 2 STEAM | BOILER No. 2 METER | BOILER No. 2 COAL | BOILER No. 3 METER | BOILER No. 3 STEAM | BOILER No. 3 METER | BOILER No. 3 COAL | TOTAL STEAM | TOTAL COAL
(E) Form 1801—11.26—5000
The Milwaukee Electric Railway and Light Company
No. 17634
COAL TEST
Kind sample "M.W. Aug."
Received from Pittsburgh Plate Glass Company
Received 8/30/27 Tested 8/31/27
Moisture 2.9 Dry Sample B. T. U. (Dry Coal) 13118
Volatile Matter B. T. U. (as rec'd) 12738
Fixed Carbon
Ash 11.60
Total
Sulphur 1.22
(F) Form 1801—11.26—5000
The Milwaukee Electric Railway and Light Company
No. 17476
COAL TEST
Kind Sample #C - July
Received from Pittsburgh Plate Glass Co.
Received 8/5/27 Tested 8/8/27
Moisture 2.5 Dry Sample B. T. U. (Dry Coal) 13647
Volatile Matter B. T. U. (as rec'd) 13306
Fixed Carbon
Ash 9.04
Total
Sulphur 0.89
W. D. Glamm
(G) The Milwaukee Electric Railway and Lu
COAL TEST
Kind Sample #1 1/27/27 E
Received from Pittsburgh Plate Glass Co.
Received 1/28/27 Tested 1/31/27
Moisture 10.4 Dry Sample B. T. U. (Dry Coal) 14146
Volatile Matter B. T. U. (as rec'd) 12675
Fixed Carbon
Ash 5.58
Total
Sulphur 0.55
W. C. Glamm K

FIG. 4. PRINTED FORM USED FOR REPORT BLANKS AND TYPICAL COAL TESTS AS REPORTED BY AN OUTSIDE CHEMIST

Detailed costs by months showing building repair, machinery repair, miscellaneous supplies, wages, water, coal cost, the unit cost per 1000 lb of steam and cost per kilowatt-hour for the year 1925 are shown in Table I. Below the totals for 1925 in the same table are shown the totals for the year 1924, in which steam used was supplied from three separate power plants.

TABLE I. SEGREGATED COST OF THE STEAM AND LIGHT AND POWER SECTIONS BY MONTHS FOR THE YEAR 1925 COMPARED WITH SIMILAR COSTS FOR 1924 THE LAST YEAR THE OLD PLANTS OPERATED

	STEAM SECTION											LIGHT & POWER SECTION								
1925 Mo. of	Machy. Repair	Bldg. Repair	Misc. Supply	Wages & Salary	Water Cost	Coal Cost	Total Gross Cost	Credit for stm. in pwr.	Total lb. stm. made	Cost per M lb.	Net cost of steam section	Machy. repair	Bldg. repair	Wages & Salary	Misc. Supply	Stm. Cost for making power	Total cost of power plant	Total kw. made	Cost per kw.	Total combined Cost of steam & power plant
Jan.	145.75	24.21	247.02	643.41		2752.85	3813.24	1422.30	10200000	37	2390.94					1422.30	1422.30	94820	.0150	3813.24
Feb.	280.60	369.51	398.14	692.28		3583.90	5324.43	236.05	11944000	44	5088.38	41.89	21.15	115.00		112.85	290.87	113170	.0025	5379.25
Mar.	127.94	37.66	234.34	588.94		3537.78	4526.66	1408.10	12931000	35	3118.56			103.92	1.05	1408.10	1513.07	115075	.0134	4631.63
Apr.	114.20	42.71	193.08	705.41	223.66	2961.62	4240.68	2002.01	10810548	39	2238.67			124.48		2002.01	2126.49	107838	.0197	4365.16
May	382.78	24.74	342.96	553.10		2386.95	3630.53	1772.21	8180543	44	1868.32			184.00	23.37	1772.21	1979.58	94777	.0209	3837.90
June	196.87		102.11	473.37		2080.29	2852.64	1855.11	6513900	44	997.53			190.00		1855.11	2045.11	85650	.0239	3042.64
July	100.06		339.06	454.18	277.65	1338.47	2509.42	1891.63	5943682	42	617.79			190.00	27.44	1891.63	2109.07	72512	.0291	2726.86
Aug.	256.74		134.50	500.35		1851.78	2743.37	2220.25	6210352	48	523.12			173.11	311.05	2220.25	2704.41	81476	.0305	3227.53
Sept.	337.11	9.57	193.47	561.28		1702.12	2803.55	2130.11	5967888	47	673.44			76.54		2130.11	2206.65	77846	.028	2880.09
Oct.	326.88		206.88	523.37	248.72	2153.19	3459.04	1482.73	8543639	40	1976.31			130.00	124.53	1482.73	1747.26	103928	.0168	3723.57
Nov.	335.42	19.46	168.87	491.35		2736.53	3751.63	1206.35	9434663	40	2545.28			125.00	128.29	1206.35	1459.64	84610	.0172	4004.92
Dec.	140.38	2.18	48.28	524.80		3753.09	4468.73	1312.59	1225832	36	3156.14			174.94	84.87	1312.59	1572.40	101534	.0155	4728.54
	2684.73	530.04	2608.71	6711.84	750.03	30838.57	44123.92	18939.44	109886535	40	25184.48	41.89	21.15	1586.99	710.60	18816.22	21176.85	1133236	.0186	46361.33 + 123.22
1924	474.62	822.47	2535.97	8806.05	266.92	28278.06			47930000	82	39784.09						11390.65	590342	.0190	50174.74

Unit costs during the year dropped from \$0.82 to \$0.40 per 1000 lb. of steam, and from \$0.019 to \$0.186 per kw-hr. As stated previously, this represents a saving of \$46,829 based on the 1924 steam cost and power at \$0.015 per kw-hr. Depreciation at 5 per cent and interest at 6 per cent, based on the boiler room investment of \$180,000, would increase steam cost \$0.08 to \$0.10 per 1000 lb. respectively, while taxes based on an assessed valuation of 67 per cent amounted to \$0.03 per 1000 lb. of steam, bringing the total cost of steam for the year 1925 up to \$0.61 per 1000 lb. In 1926 the manufacturing cost had decreased from \$0.40 to \$0.37 per 1000, depreciation, interest and factors remaining practically the same.

In 1926 the evaporation per pound of coal was 8.5 lb. This was increased to 8.7 lb. in 1927 although the unit cost of steam increased to \$0.4239 per 1000 lb. as shown in Table II. This increased cost in spite of better evaporation was due to the installation of new baffles and furnace linings costing \$1500. This occurred but once in the 3 yr. operation and charged entirely against the 1927 operating expenses, of course, raised the unit cost unduly. Furthermore, new coal contracts starting in July, 1927, changed conditions somewhat so that a comparison of unit costs covers two different prices.

Samples are taken of every coal delivery, and a composite sample made up for the month. This sample is split in three parts, one sent to the coal company, one is sealed in a tin can and kept till the end of the year, and a third sample is analyzed either by the company chemist or by the chemist for the Milwaukee Electric Railway & Light Co. This sample is tested for moisture, ash, sulphur and B.t.u. content and reported back as shown in Fig. 4 E, F and G. Water samples are also taken and analyzed regularly.

Engineer's Reports Go to Accounting Department

The engineer's reports, Fig. 4 A, B, C and D are made up each month and sent to the Accounting Department to make up a tabulation showing data for month just ended, the preceding month and the corresponding month a year ago. A typical tabulation for August, 1927, is shown in Table III. This gives not only the high pressure steam, low pressure steam and power consumption for various departments, but shows the total coal consumed, power generated, the boiler horsepower developed, evaporation, the steam cost and the power cost. Three different coals have been used and typical tests are shown in Fig. 4 E. F. and G, representing Virginia split, Fairmont screenings and Elchorn, respectively. Corresponding evaporation in pounds of water per pound of coal are given in Col. 1, 2 and 3, Table II, for the three coals and amount to 8.44, 9.104 and 9.91 lb. of water per lb. of coal, respectively, for the 13,118, 13,647 and 14,146-B.t.u. coal. Similar reports for December, 1927, show an evaporation of 8.5 lb. with \$5.10 coal and for November an evaporation of 8.7 lb. with \$4.90 coal. The developd b.hp. during the month being 434,398 and 263,925, respectively, for December and November.

Sufficient instruments to allow intelligent operation are provided and each boiler, in addition to the pressure

TABLE II. DETAILED COSTS FOR THE YEAR 1927 AND UNIT COSTS FOR 1926

	STEAM SECTION														POWER SECTION										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20 *	21	23	24	25	26	27
1927	Wages and Salaries	Mach. Repair	Bldg. Repair	Misc. Supplies	Water Cost	Coal Tons	Price per Ton	Cost of Coal	Lb. Steam M	Steam for Power M	Net Steam Proc.	Fuel Cost Steam Per M	Total Steam Cost	Steam Cost Per M lb.	Cost of Steam For Power	Net Cost of Steam Plant	Steam For Power	Wages and Salaries	Mach. Repairs	Misc. Supplies	Total Power Cost	Total kw. hr. Produced	Cost per Kw.hr.	Total Power Plant Cost	1927
Jan.	573.91	431.20		94.75	125.00	908	4.65	4307.04	13363	3191	10172	.3220	5406.90	.4045	1291.15	4115.75	1291.16	64.00			1355.15	107808	.0126	5470.90	Jan.
Feb.	604.88	400.58		144.82	125.00	744	4.65	3577.00	13993	3500	10493	.2556	4726.72	.3376	1182.24	3544.48	1182.24	60.00			1242.24	121036	.0103	4786.72	Feb.
Mar.	892.06	519.56		148.17	139.70	648	5.00	3240.00	11608	2508	9100	.2791	4890.48	.4213	1056.62	3833.86	1056.62	65.90		62.12	1184.64	111236	.0106	5018.47	Mar.
Apr.	473.70	178.68		94.61	125.00	695#	5.00	3477.50	11944	4278	7666	.2911	4549.49	.3809	1629.49	2920.00	1629.49	75.00	27.38	11.03	1742.90	118723	.0151	4662.90	Apr.
May	658.49	233.03		21.12	125.00	500	4.65	2325.00	9411	4494	4917	.2471	3812.64	.3520	1581.89	1730.75	1581.89	67.60	6.53	107.54	1763.88	107097	.0165	3494.52	May
June	609.88	342.64		183.81	83.15	363	4.65	1687.95	6297	3097	3200	.2359	2877.43	.4362	1350.91	1526.52	1350.91	67.76	70.83		1489.50	101727	.0144	2016.12	June
July	643.42	424.22	8.69	157.66	83.15	306#	4.90	1496.95	5563	3193	2370	.2691	2814.09	.5058	1615.02	1199.07	1615.02	69.76	92.87		1777.35	82991	.0214	2976.42	July
Aug.	580.83	269.26		48.44	100.00	389#	5.10	1986.45	6578	4751	1827	.3020	2979.98	.4530	2152.20	827.78	2152.20	65.00	137.44		2354.84	98618	.0239	3182.64	Aug.
Sept.	583.52	382.11	10.75	176.17	100.00	405	4.90	1984.50	7412	5082	2330	.2677	3437.05	.4639	2356.52	1080.53	2356.52	64.84	117.93	30.03	2569.32	93800	.0268	3649.68	Sept
Oct.	599.89	349.55	3.41	94.68	125.40	382#	5.10	1949.48	6596	2864	3732	.2954	3152.51	.4779	1368.70	1783.81	1368.70	64.53	196.78	22.28	1654.41	94450	.0175	3456.22	Oct.
Nov.	685.70	437.35		107.42	161.60	515#	4.90	2525.95	8973	2761	6212	.2815	4118.02	.4589	1267.02	2851.00	1267.02	76.00	348.07	32.40	1723.49	84810	.0203	4574.49	Nov.
Dec.	798.33	342.11		104.32	161.60	869	5.10	4431.90	14780	3298	11482	.2999	5836.24	.3948	1302.05	4533.21	1302.05	88.37	169.67	55.04	1615.13	101500	.0159	6148.34	Dec.
														Ave.									Ave.		
Total	7582.40	4710.39	22.85	1340.41	1484.60	6725#		32989.72	116818	43017	73801	.2805	43100.57	.4239	19153.81	29946.76	18153.81	830.88	1167.52	320.46	20472.67	1322798	.0172	50419.43	
1927					12,460,500#				116,818,000#				43,100.57	.4239	(Evaporation 8.7 at 175# 100 deg. Superheat)										
1926					14,600,000#		#34,040.95		124,737,284#				#48,072.55	.385	(Evaporation 8.5 at 175# 100 deg. F. Superheat)										

NOTE: New coal contracts starting July 1 comparison covers unit costs of two different priced coals. Col. 3 includes new baffles & furnace linings \$1500.00 once in 3 years. These notes explain increased unit cost of steam in spite of increased evaporation rate. *Col. 21. Bldg. repairs for Power Section omitted - no charge during year

TABLE III. TYPICAL MONTHLY REPORT SHOWING THREE MONTHS ON SINGLE SHEET FOR PURPOSES OF COMPARISON

h. P. Steam	August 1927	July 1927	August 1926
Corona	295,800 lb.	507,732 lb.	106,894 lb.
Paint plant	475,664 lb.	430,050 lb.	593,093 lb.
H.P. to L.P. system	1,055,390 lb.	1,431,900 lb.	1,125,650 lb.
Power	4,750,874 lb.	3,193,504 lb.	6,391,579 lb.
Total H.P. steam	6,577,728 lb.	5,563,186 lb.	8,367,216 lb.
L. P. Steam			
Corona	670,320 lb.	357,490 lb.	849,340 lb.
Paint plant	133,180 lb.	822,580 lb.	100,000 lb.
Office	100,630 lb.	100,900 lb.	75,000 lb.
Varnish Plant	101,260 lb.	100,930 lb.	101,310 lb.
Mimax	50,000 lb.	50,000 lb.	
Total L.P. steam	1,055,390 lb.	1,431,900 lb.	1,125,650 lb.
Power			
Corona	19,500 K.W.H.	12,350 K.W.H.	23,500 K.W.H.
Paint plant	32,400 K.W.H.	28,670 K.W.H.	33,820 K.W.H.
Office	14,630 K.W.H.	12,770 K.W.H.	13,310 K.W.H.
Enamel	21,630 K.W.H.	19,360 K.W.H.	26,660 K.W.H.
Varnish	3,700 K.W.H.	3,260 K.W.H.	4,960 K.W.H.
Power Plant	6,752 K.W.H.	6,581 K.W.H.	5,976 K.W.H.
Total K.W.H.	98,612 K.W.H.	82,991 K.W.H.	108,226 K.W.H.
Coal consumed	778,860 lb.	611,030 lb.	843,600 lb.
Power generated	98,612 K.W.H.	82,991 K.W.H.	108,226 K.W.H.
B. Hp. developed	192,462 B.Hp.	163,622 B.Hp.	246,094 B.Hp.
Evaporation	8.44 lb.	9.104 lb.	9.91 lb.
Steam cost			Elchorn coal
Power Cost			

gage and flow meter indicator is provided with a triplex draft gage and recording thermometer on the uptake. The draft gage records the draft at the fan, in the last pass of the boiler and in the furnace. Recording gages on the soot blower and blow down lines are used for indicating the time at which the soot blowers and blow down valves are operated. A combination CO_2 and draft gage records CO_2 and draft in the boiler breeching, while recording pressure and temperature gages record the steam pressure and temperature in the header and the feedwater temperature to the boilers.

Not only are these instruments provided, but they are so tied in with reports that it is important that they must be kept in operation and check reasonably close. Operating conditions have been steadily improving and the CO_2 content now runs around 10 per cent. On December 15, 1926, a boiler test, carried on by an outside consulting engineer, gave the results shown in Table IV, representing an efficiency of 78.7 per cent. The average CO_2 during the test is shown in Fig. 5-E, and averages about 6 per cent, as compared with the average of about 10 per cent shown by the chart, Fig. 5-D, made September 15, 1927, nine months later.

TABLE IV. RESULTS OF A BOILER TEST MADE BY OUTSIDE ENGINEERS

Number and kind of boilers	2 353-hp. Heine
Baffles	Horizontal
Stokers	Type E, Underfeed
Duration of test	3½ hours
Coal as fired	9600 lb.
B.t.u. in coal as fired	12,888 B.t.u.
Approximate analysis	
Moisture	6.06 per cent
Ash	8.22 per cent
Volatile	32.37 per cent
Fixed Carbon	53.35 per cent
Sulphur	1.16 per cent
Cold water fed to heater	1290 cu. ft.
Average temperature cold water	38 deg.
Average temperature hot water to boiler	209.4 deg.
Cold water fed to heater	80,496 lb.
B.t.u. added to cold water in heater	13,797,014 B.t.u.
Exhaust steam pressure	3 lb.
B.t.u. obtained per lb. in exhaust steam	996.9 B.t.u.
Quantity exhaust steam condensed	14,270 lb.
Total water fed to boiler	94,766 lb.
Actual evaporation	9.85 lb.
Steam pressure	175 lb.
B.t.u. required to make 1 lb. steam	1.020 B.t.u.
Total B.t.u. absorbed	96,661,320 B.t.u.
Total moisture in coal as fired	582 lb.
Average stack temperature	570 deg.
Heat wasted in moisture	750,000 B.t.u.
Total heat in coal as fired	123,724,800 B.t.u.
Heat available in coal	122,974,800 B.t.u.
Per cent efficiency	78.7 per cent

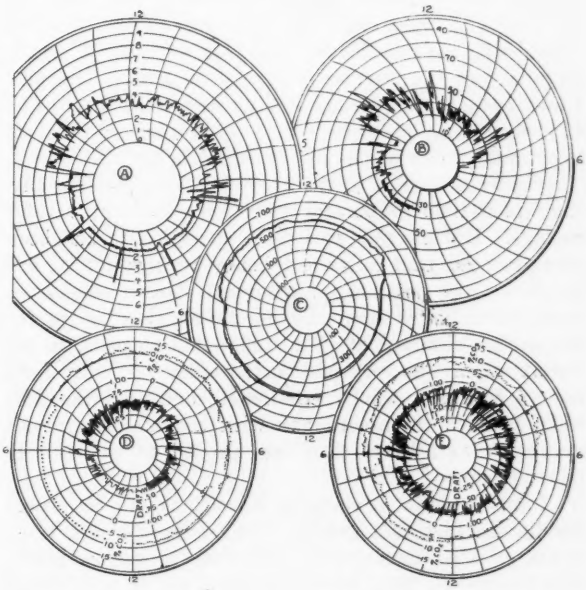


FIG. 5. TYPICAL CHARTS SHOWING OPERATING CONDITIONS AT THE PLANT: A. FEEDWATER METER RECORD, B. STEAM FLOW FROM BOILER NO. 2, C. EXIT GAS TEMPERATURE OF BOILER NO. 2, D. CO_2 AND DRAFT CONDITIONS ON SEPTEMBER 15, SHOWING THE IMPROVEMENT IN CO_2 OVER RESULTS OBTAINED IN THE TESTS REPORTED ON DECEMBER 15 OF THE PREVIOUS YEAR AS SHOWN BY E

Instruments play an important part in helping the operator maintain maximum efficiency. It is not, however, until the reports are made and the data obtained that their benefit to the organization is obtained. By sending the engineer's report direct to the accounting department, The Pittsburgh Plate Glass Co. is not only eliminating intermediate departments and corresponding sources of error, but has also impressed upon the operating department the importance of the records which they are keeping, making them feel that their reports and results obtained are actually of some use and service to the company.

BEFORE MAKING a statement ask yourself, "Are you sure?"

Boiler Tests with Unit Mills at Cahokia

THREE MONTHS' CONTINUOUS OPERATION OF NEW BOILER UNIT HAS PROVED ENTIRELY SATISFACTORY. BY E. H. TENNEY*

IN THE LATEST EXTENSION to the Cahokia Station of the Union Electric Light & Power Co. at St. Louis, Mo., three 1800-hp. B. & W. boilers are installed. Each has a 3789-sq. ft. convection type superheater, a B. F. Sturtevant Co. 9920-sq. ft. air preheater, one 180,000-cu. ft. per min. Sturtevant induced draft fan, and two 32,500-cu. ft. per min. Sturtevant forced draft fans.

Each boiler is fired by two Simplex unit pulverizers with a capacity of 15,000 lb. per hr. each, using 4-in. white iron paddles. The furnace has a combustion space of 12,400 cu. ft. and is equipped with four 18-in. Bailey-Tenney forced draft burners. Side walls, rear wall, ash pit floor and water arch are all water cooled, recessed tubes being used on the side and rear walls and Furnace Engineering Co. furnace bottom and arch. The projected areas of the various cooling surfaces are 465, 238, 475, and 93 sq. ft. for the side walls, rear wall, ashpit floor and arch respectively, the total being 1275 sq. ft. They have now been in operation for three months, during which time evaporator tests were made at various ratings. During this period of operation it has been demonstrated that sustained boiler ratings up to 400 per cent are possible; that overall boiler efficiencies equal to or better than any heretofore obtained in the station are obtained at all ratings; that slagging in the ashpit which was very bad in the older vertically fired boilers is almost wholly eliminated, and that the unit mills perform in accordance with the manufacturer's guarantee and have, thus far, proved to be entirely dependable.

Improvements in slagging conditions are accounted for by the fact that the hot zone of the furnace is no longer located immediately above or in the ashpit as was the case in the other installation, but is now higher up toward the center of the furnace, where the heat is dissipated to the side wall heating surfaces rather than to the ash in the ashpit.

More extended observation and experiment along the line of the most favorable fuel grind for various boiler ratings will be required before the most favorable operating points of the mill can be definitely established. Up to this time the indications are that excellent furnace conditions are obtained with a maximum fineness of grind of 65 per cent through 200 mesh and 1¼ per cent as the maximum remaining on the 40 mesh screen. Test results reported in the table were run on boiler No. 17, a cross section of which is shown in Fig. 2.

BOILER FIRED WITH TURBULENT BURNERS

Four turbulent type burners shown in Fig. 2 are set horizontally across the setting with secondary preheated air admitted to a housing around each burner, the vanes imparting the desired turbulence. A new design of fuel deflector is used at the burner outlet which consists of spirally set vanes, taking the place of the solid cone deflector heretofore used. This arrangement more effectively breaks up the fuel stream, at the same time blowing the fuel out into the path of the

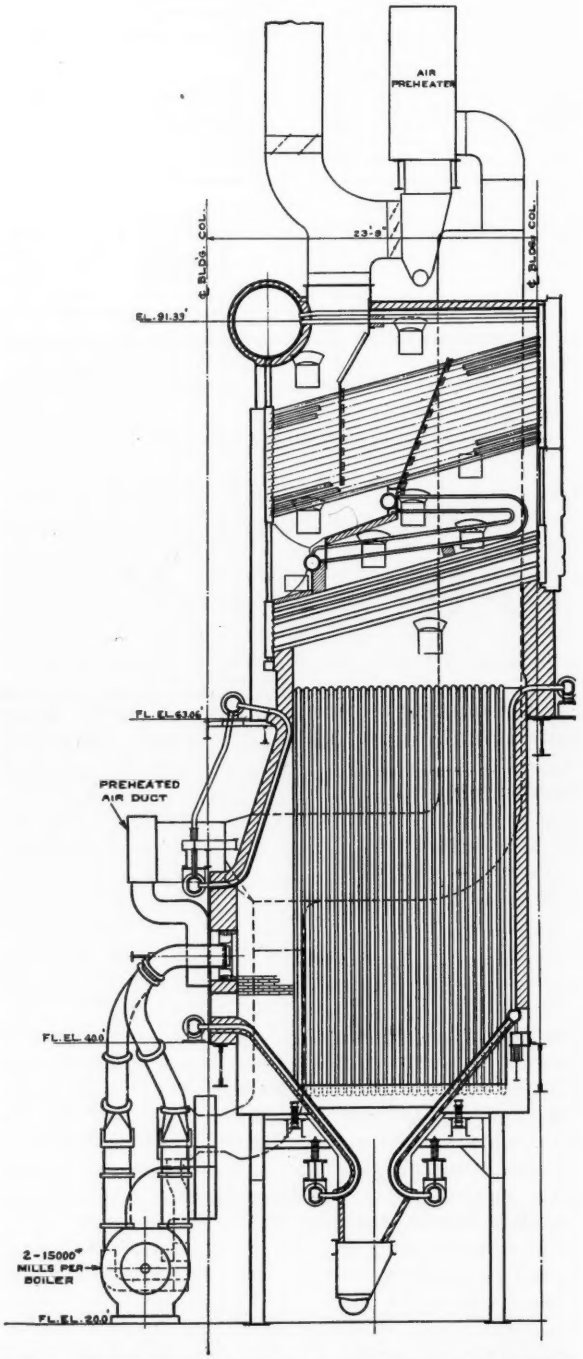


FIG. 1. CROSS SECTION OF BOILER NO. 17 UPON WHICH THE REPORTED TESTS WERE MADE

*Chief Engineer of Power Plants, Union Electric Light & Power Co., St. Louis, Mo.

secondary air. The combined effect is maximum turbulence resulting in a uniformity of gas quality throughout the furnace.

Although the installation was designed for Illinois coal, the plant has been recently using West Kentucky coal as a result of the recent miners' strike. The two fuels are very similar except that the West Kentucky

TEST RESULTS ON BOILER NO. 17 AT CAHOKIA

Per cent rating, boiler only	165		278		382	
Steam evap., lb. per hr.	83,078		139,036		190,343	
Water evap. per lb. coal, lb.	8.701		8.203		7.578	
B.t.u. liberated per cu.ft. combustion space per hr.	9,020		15,804		23,373	
Eff. of boiler with preheater	88.85		85.78		79.50	
Steam press., abs.	328		335		344	
Total temp. of steam, deg. F.	685		709		729	
Superheat	259		281		299	
Temp. flue-gas, boiler outlet	463		511		562	
Temp. flue-gas from preheater	287		375		457	
Temp. air from preheater	205		263		264	
Draft loss, air preheater, in H_2O	0.15		0.73		3.41	
Carbon dioxide	16.1		15.5		14.6	
Heat value per lb. coal as fired, B.t.u.	11,722		11,562		11,538	
Ash, per cent	15.60		15.02		15.52	
Moisture, per cent	5.44		6.12		5.97	
	A	B	A	B	A	B
Per cent through 40 mesh	99.5	99.3	98.8	98.0	94.5	96.6
Per cent through 200 mesh	80.7	77.2	70.4	70.1	58.8	54.0
Mill	27.90		18.47		13.4	

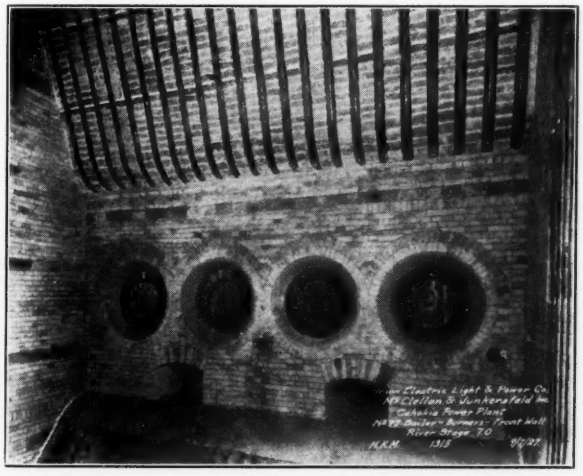


FIG. 2. FRONT WALL OF NO. 17 BOILER WITH RECESSED TILE IN THE FRONT WALL AND WATER COOLED FLOOR OF THE CAST-ON BLOCK TYPE

coal has a higher heat content and is lower in moisture and ash, the percentage being 8 and 14 respectively as compared to 11 and 15 per cent in Illinois coal. The ash fusing temperature of the two coals is similar, this temperature being 2010 deg. F. for Illinois coal and 1976 deg. F. for Kentucky coal.

CONVERSION of coal into coal oil by the Bergius method, in addition to insuring a large additional source of fuel for the future, permits the working up of heavy oil residues and distillates, asphalts and tars—now used for other purposes—into gasoline, alcohol, and a number of other valuable by-products. Continued development of this process means a steadily declining trend during the next few years in oil exports to Germany. It also means an increase in the value of all low-grade coal deposits. Any commercial development of such processes in the United States will, however, follow a more leisurely course, because of our present extensive petroleum resources.

Progress in Oil and Gas-Power Engineering

GREATEST PROGRESS HAS BEEN MADE IN THE AUTOMOTIVE AND MARINE FIELDS HENCE MOST DEVELOPMENT IS FOUND IN BOTH SMALL SIZED AND LARGE HIGH POWERED UNITS*

WHILE THE preceding two or three years of oil-engine history were characterized by increasing compression pressures, 1927 has marked the beginning of what may prove to be a long struggle for higher speeds. The pressure increases that have taken place in recent years in several manufacturers' products were effected not so much with the aim for higher output as for the sake of convenience in operation. Cold starting was the object; occasionally also the elimination of water injection. As a result of this tendency, the low-compression or semi-Diesel engine which a few years ago represented the majority of oil-engine horsepower manufactured almost disappeared from the picture in 1927.

HIGHER SPEED AND LOWER WEIGHT REPRESENTS TREND

The present trend is unmistakably toward higher speeds in order to obtain more power per pound of engine weight. The incentive is the conquest of the mobile field for the heavy-oil engine. The distinction of having attained the greatest recent progress therein belongs to the Diesel locomotive.

From a timid beginning a few years ago, we have at present an established type of switching locomotive in the United States, used by at least ten railroads and several industrial companies with satisfaction and effecting considerable saving. The British Company is now building 12 by 12-in., 12-cylinder V-type engines developing 1200b.hp. at 750 r.p.m. with an overload capacity of 1500 b.hp. at 900 r.p.m. The complete engine weighs 22,000 lb., or about 18 lb. per hp. Such an extremely low weight for this type of engine is a truly remarkable engineering achievement. Two of these engines, giving a total of 3000 hp., are now being built in one large locomotive, giving a tractive effort of 100,000 lb., and hauling a 750-t. passenger train at 70 mi. per hour.

GIANT DIESELS ENTER THE FIELD

Looking at the other end of the picture, the progress made in high-powered Diesels is no less gratifying. Shipbuilders are the best customers for large Diesels. The increased popularity of the Diesel with ship owners is shown by Lloyd's figures. On September 30, 1,163,630 i.hp. of marine oil engines were under construction against 586,969 i.hp. of reciprocating steam engines and 309,900 hp. of turbines. Oil-engine tonnage increased to 52½ per cent from 19½ per cent 4 yr. ago. From a spectacular standpoint the most outstanding installations were single engines of the Doxford opposed-piston, airless-injection type, 5000 screw hp. in four cylinders, in two single-screw vessels; and single engines of the Burmeister & Wain double-acting, four-cycle type, 9000 screw hp. in eight cylinders, in three double-screw vessels. The latest set of these, installed in the Saturnia,

*Abstract of report of the Oil and Gas-Power Section of the A. S. M. E. submitted Dec. 8, 1927, by Professor P. H. Schweitzer during the annual meeting held in New York City.

is supercharged with two electrically driven turbo-blowers, which increases the output of each engine to 10,000 screw hp. The Augustus, the largest motorship in the world, 33,000 gross t., equipped with four M. A. N. engines, 700 screw hp. each, has made her maiden voyage this November. The largest cylinder output ever attained was obtained this year from a Sulzer experimental one-cylinder engine, delivering 2900 i.hp.

In the stationary field more high-power Diesels are being installed in electric central stations. In the Commerce Mining and Royalty Plant in Oklahoma, three Nordberg two-cycle engines have been installed totaling 6750 b.hp. The favorable experience with the 15,000-hp. Diesel engine installed in 1926 for the Hamburg Electrical Works induced a Berlin electric-power company to place orders with M. A. N. for two 10-cylinder, 12,000-hp. engines, 215 r.p.m. (21.3 ft. per sec. piston speed), to be used as stand-bys. America's largest Diesel power plant, the Panama Canal plant at Miraflores, consisting of three single-acting, two-cycle Nordberg engines and having a peak load capacity of 12,375 hp., has been completed this year and serves a similar purpose.

Diesel, in Standby Service, Offers Much Return

It is readily admitted that unless favored by particular local conditions, the Diesel engine cannot compete with steam and water turbines for large power generation. On the other hand, both calculations and experience have shown convincingly that their combination with steam and water power for peak loads and emergencies offers decided economical advantages. For short-period operations, the higher fuel cost of the Diesel is more than offset by its lower interest on first cost compared with water power and by its lower cost of keeping it prepared for emergency, compared with steam power. The water-power central station at Bremen installed two 3000-hp. Sulzer Diesel units to co-operate with water turbines. The 4500-hp. Diesel set of the Societe des Forces Motrices du Refrain operates satisfactorily together with water and steam turbines. The possibilities of the Diesel engine for central stations are not yet fully realized.

Among the recent changes, the popular adoption of the box frame and the improvement of the exterior appearance of the engines are most noticeable. On the other hand, more and more engineering skill is being applied to production. Refined finishing methods are finding their way into Diesel machine-shop practice. Grinding and honing of cylinders, broaching of wristpin bushings and lapping of spray needles, pump plungers, and even valve sets are used with success. Larger builders have made progressive steps toward continuous production of engine units, using interchangeable parts, conveyors, and systemized material-handling methods.

The manufacture of small and medium-size gas engines has lost its significance since the advent of the gasoline and Diesel-type engines. Where industrial gas is available as a by-product of blast-furnace and steel-mill operations, large gas engines are still most economical generators of power. Allis-Chalmers Mfg. Co. is building gas engines in units up to 4000 hp.

Many good accessories which have recently been placed on the market, either increase the usefulness of oil engines or relieve their builders from making such items themselves. Air and oil filters, centrifuges for lubricating and fuel oil, charging and scavenging blowers, distant-reading cooling-water and exhaust thermometers, and high-speed indicators are only a few of a worthy list. Fuel pumps and spray nozzles were not considered accessories until recently, yet at least one foreign and one American manufacturer are contemplating manufacturing these delicate engine parts and selling them to the oil engine builders. Such a specialization in manufacture will probably further reduce the cost and increase the utility of the oil engine.

Modern Trends in Diesel Practice

While accurate figures are not easily obtainable, the trend is unmistakably toward hydraulic (solid) injection. Out of the total horsepower of stationary engines built in this country, 53 per cent was of the airless-injection type in 1924, 56 per cent in 1925, and 58 per cent in 1926, excluding the low-compression engines. In Germany and England this trend is still more pronounced. Hydraulic injection is not yet generally applied to the largest sizes, but Doxford and Burmeister & Wain have recently built airless-injection engines with 1250 and 1125-hp. cylinder capacities, respectively. It is being tried experimentally both on the Sulzer double-acting engine and on the Harland-B. W. design. The struggle between two-cycle and four-cycle is still undecided. The respective figures in per cent of total horsepower for American stationary engines for the last 3 yr. are as follows:

	1924	1925	1926 (Estimated)
Two-cycle	42	51	49
Four-cycle	58	49	51

In marine application the two-cycle seems to gain over the four-cycle, while for locomotives the opposite is the case. The most spectacular advance, however, has been made by the double-acting principle. Not long ago, double-acting engines were considered experimental, but now there are six different makes of double-acting engines in operation at sea and five more in a very advanced degree of development.

As regards construction, a trend toward more rigid frames is noticeable. The A-frame is being displaced by the box frame with individual or cast-in-block cylinders. Rigid connections between the individual cylinders or cylinder heads frequently serve the same purpose. The reduced vibration and bearing wear achieved with the rigid construction justify the additional expense. The chain drive of the camshaft, introduced not long ago, has won further adherents. The use of aluminum and alloys for pistons is being tried with promising results. The use of high-grade materials for other engine parts together with refined finishing methods is also progressing especially with high-speed machinery.

Efforts are being made to secure higher mean effective pressures for two-cycle engines. Crankcase scavenging is slowly losing ground, while the use of blowers is gaining for both charging two-cycle and supercharging four-cycle engines. At present the employment of blowers is restricted to large engines, but their introduction for medium and small engines is predicted.

In the controversy over direct spray injection as

against a precombustion chamber, both parties are holding their ground, and no gain for either can be recorded. New injection systems are still being introduced and a perplexing number of varieties are already available. Some of those recently developed take a middle place between the direct pump injection and the accumulator (common rail) system, by accumulating with each pump stroke only fuel enough for one injection, and using a mechanically operated valve for timing the injection. The possibility of controlling turbulence by directing the intake air has been finely established by the Hesselman, Krupp, Junkers and Langley Field experiments, proving conclusively that the rotation of the air is not killed by the compression. German designers have already taken advantage of this fact, apparently with good results.

By superchanging with the Buchi system, using exhaust turbines for driving the blowers, the Swiss Locomotive Works has succeeded in increasing the rating of a four-cycle engine by not less than 50 per cent without any increase of the exhaust temperature, if reports are reliable.

Modern Production Methods and More Specially Trained Men, Need of Industry

It would perhaps be futile to deny that our oil-engine industry is not taking the place that it rightfully deserves. On September 30 out of 1,163,630 i.hp. of marine oil engines under construction in the world, only 13,090 were being built in the United States, compared with 365,440 in Great Britain, 244,370 in Germany, and 157,850 in Italy. It is true also that fewer ships were under construction in this country than in those mentioned, but certainly not less than in Switzerland. Yet Switzerland is building 6½ times as many (85,000 i.hp.) marine Diesels as we are. As stated before, 52½ per cent of the merchant vessels under construction in the world are motorships, but only 14.4 per cent of these are of American tonnage. With 76 per cent of the world's petroleum produced in this country, it is very safe to say that less than 10 per cent of the oil engines are made here. Some of the reasons for this are that production costs are high, competition of the electric-power companies is destructive and power users have not sufficient confidence in oil engines.

Research, preferably co-operative research, would help produce more efficient engines. The cut-and-try method which is being practiced now is the most expensive of all, and will continue to be as long as we are in the dark as to the fundamentals.

Reduction in production costs would be achieved by specialization and adoption of modern production methods. The "part maker," a familiar figure in the automobile industry, has a justified place in the oil-engine industry as well. Few oil-engine builders are equipped to produce high-quality pistons, fuel pumps and injection nozzles economically. Making fewer parts in larger quantities, we shall be able to adopt methods of quantity production: interchangeability, the use of jigs and fixtures and rapid-inspection gages; adopt continuous synchronized production, and do away with chalk and file and large part storage.

The industry needs more trained men. A greater supply of skilled oil-engine operators would undoubtedly improve the market. We need more factory men skilled in erecting Diesel engines and machining delicate engine parts. We need more field service men able to diagnose troubles and give proper service to customers. We need more engineers trained in the design and developments of Diesel engines, men with sufficient theoretical background and some familiarity with the work that has already been done on the subject.

Welded Plate Construction Used for Machinery

ELECTRIC WELDING is increasing in various branches of mechanical construction, the development of welded plate fabrication in the electrical industry being especially marked during the last few years.

Among the applications for which arc welding is used by the General Electric Co. are magnet frames and armature spiders for direct-current machinery,

INSIDE WELDING ON A SECTION OF FRAME FOR THE STATOR OF AN ALTERNATOR

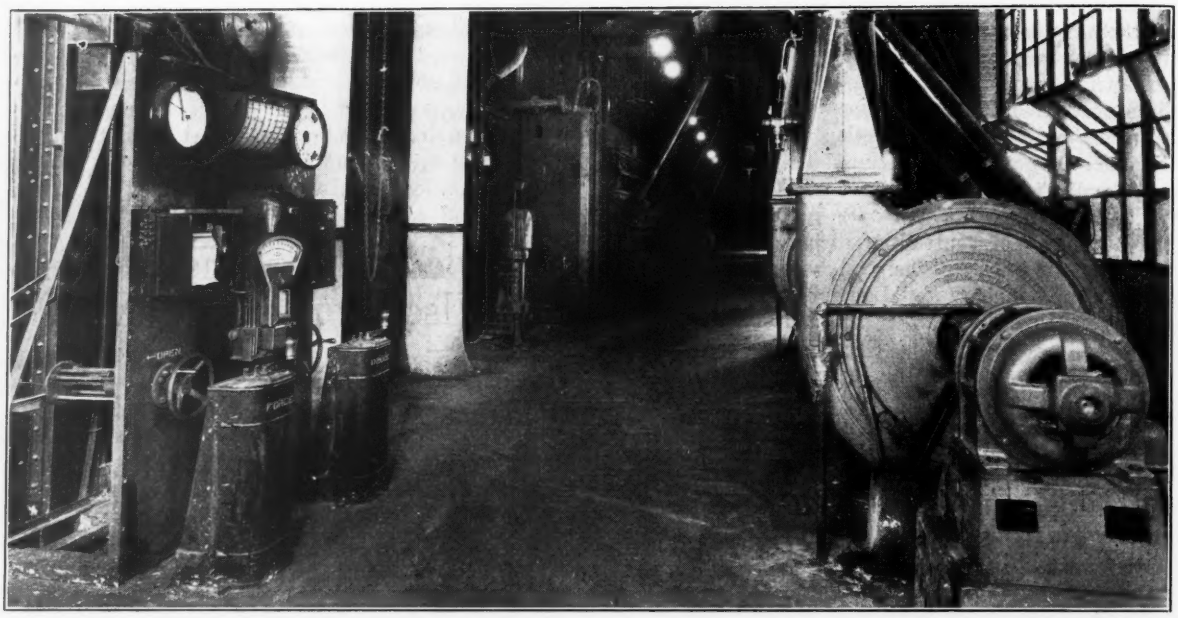
stator frames and rotor spiders for alternating-current machiney, also bases, bearing pedestals, guards and deflectors, transformer tanks and parts for control devices, switches and compressors.

This method of construction eliminates patterns, pattern storage, core ovens, foundries, chipping rooms, the time required for making the patterns, the cores and the mold, also for the casting to cool and the ever present danger of a spoiled casting or breakage.

For large electrical machines, of special design and often only one of a type to be built, costly pattern work is avoided, work on such machines being started as soon as the drawings are completed.

Electrically welded plate construction in generators and motors gives smaller revolving weights, more latitude in design and with better ventilation provided.

Both hand and automatic welding are used in this work, the machines with automatic advancing electrode being capable of welding several inches of seam a minute.



Steam Generator, Feature at New Staley Plant

New Unit, Burning Pulverized Coal and Capable of Producing 150,000 Lb. Steam Per Hour Controlled by Push Buttons from Central Control Board

WITH THE STARTING up of the "Steam Generator" in the power plant of the A. E. Staley Mfg. Co. of Decatur, Ill., recently went into effect the second important development in steam generation sponsored by this company in recent years. The Staley Mfg. Co., it will be recalled by those familiar with combustion progress, pioneered in the development of the forced draft chain grate stoker and its application to the use of Illinois coal.

Before describing the details of this steam generator, it will be of interest to review briefly the history of the plant and the events which led to the selection of this type unit. Previous to the installation of this unit and the construction of the new turbine room, the power plant serving the Staley factory was similar to many other industrial plants throughout the country. It was the gradual outcome of a constantly growing factory. As more power was needed in the corn products plant, new generating and boiler units were added. Just before the construction of the new plant, the power generating equipment consisted of a boiler house, containing twelve 588-hp. and two 897-hp. boilers fitted with chain grate stokers, supplying all the steam required for process work in the factory as well as that required by the electric generating units. The latter consisted of 3 turbo-generators of 1000, 1500 and 2500 kw. respectively together with an old 350-kw. Corliss engine.

This equipment was operated as efficiently as possible under the conditions existing but as in the case at most other industrial plants, the power plant was the result of necessity rather than of careful planning. So, as the factory continued to grow and the demand for power increased, it was decided in 1925 to build a new turbine room and add more steam generating capacity.

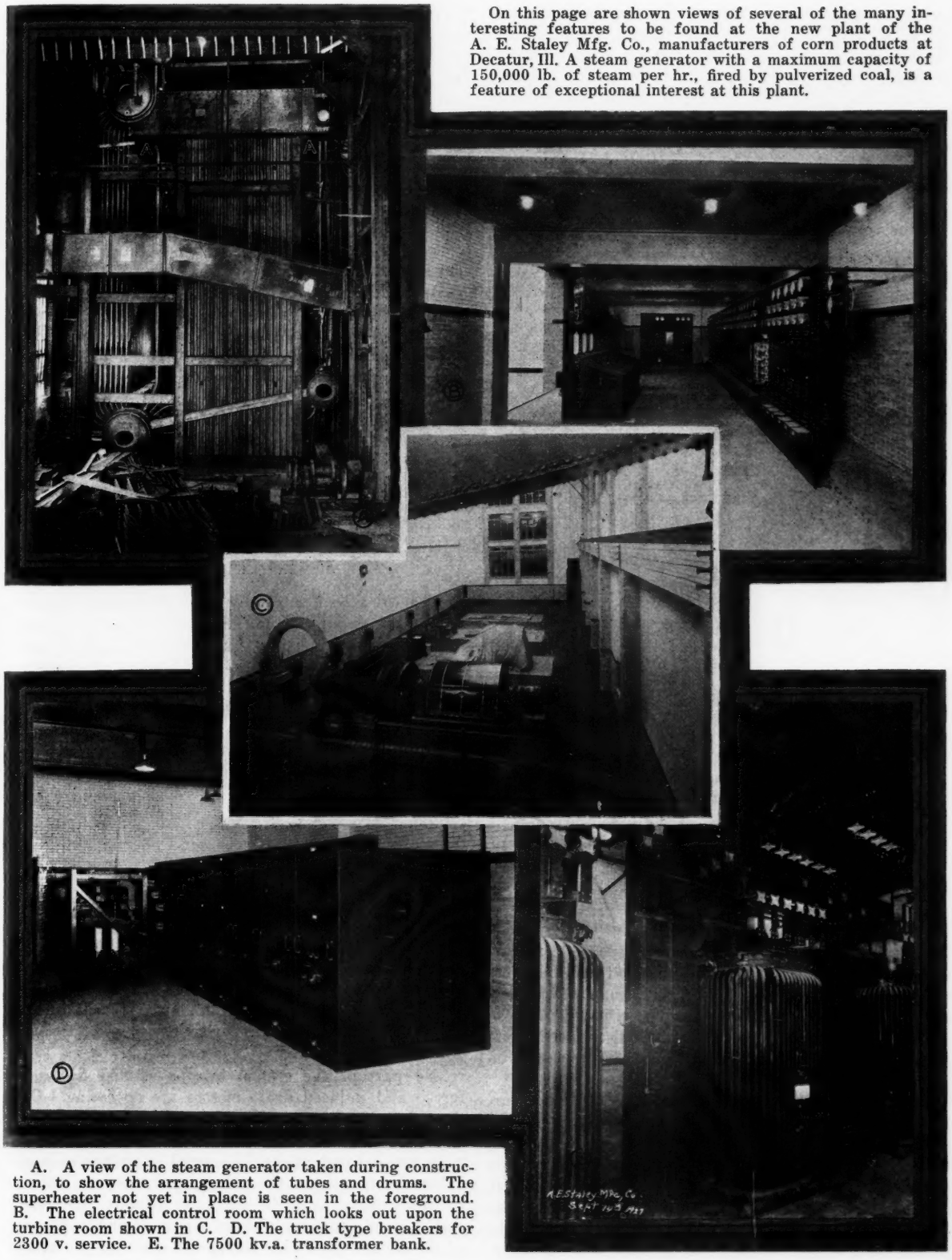
At the time these changes became necessary, the power plant was under the direction of the present chief operating engineer, Geo. F. Klein, a man with wide experience in power plant engineering, particularly with respect to central station practice in the use of pulverized coal. This fact is largely responsible for the excellent appearance of the new turbine room and electrical galleries for it is apparent at once that the best principles of modern central station design have been incorporated in the new Staley plant. Appearance, however, is not the only feature which distinguishes this plant from others of its class, for with attractive appearance there have been combined engineering features of unquestioned merit.

In addition to the construction of the new turbine room, it was decided to install also a Combustion Engineering Co. steam generator, using pulverized coal as fuel. This was a radical departure from usual practice since it involved the installation of equipment of entirely new design and principles which although sound fundamentally, had not at that time been applied commercially. The installation of this steam generator in the existing boiler room together with the construction of a new turbine room building to house the three turbo-generators already installed, with a new 6000-kw. unit and an entirely new modern switchhouse, constituted the changes described in this article.

The steam generator as is probably known to many of those reading this article, is the outgrowth of a development in England and was brought to this country by the International Combustion Engineering Corporation. It differs from an ordinary boiler installation

VIEWS OF INTEREST AT THE NEW STALEY POWER PLANT

On this page are shown views of several of the many interesting features to be found at the new plant of the A. E. Staley Mfg. Co., manufacturers of corn products at Decatur, Ill. A steam generator with a maximum capacity of 150,000 lb. of steam per hr., fired by pulverized coal, is a feature of exceptional interest at this plant.



A. A view of the steam generator taken during construction, to show the arrangement of tubes and drums. The superheater not yet in place is seen in the foreground. B. The electrical control room which looks out upon the turbine room shown in C. D. The truck type breakers for 2300 v. service. E. The 7500 kv.a. transformer bank.

principally in that the boiler, that is, the heating surface, completely surrounds the furnace and is an integral part of the combustion chamber. The three outstanding features of this type of unit are: 1, the use of coal in pulverized form; 2, the practical elimination of all brickwork in the construction of the furnace and 3, large steam capacity per given cubic foot of space occupied.

Figure 2 shows a cross section of the unit as installed at the Staley plant. It consists of a fin tube type water cooled furnace provided at the bottom with a water screen and at the rear with a convection heating surface. A superheater is installed at the lower rear part of the unit in the gas path between the water screen and the convection heating surface. This superheater,

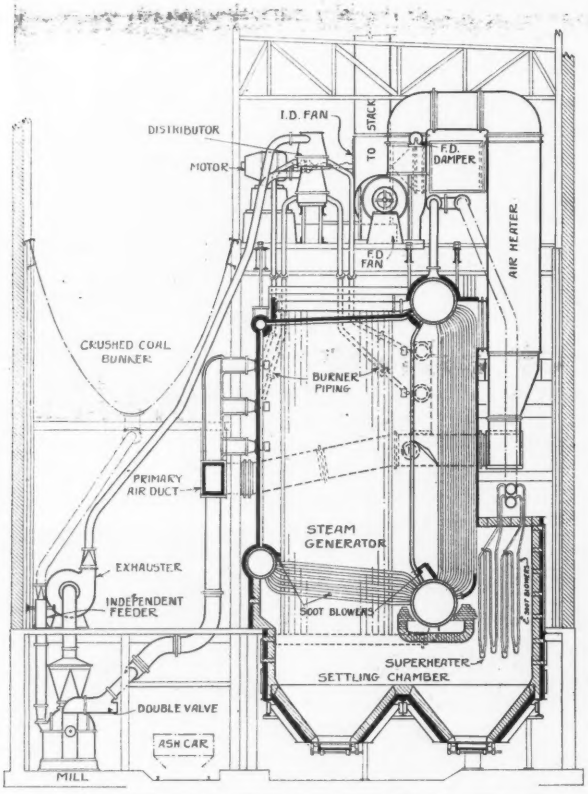


FIG. 2. SECTION THROUGH COMBUSTION STEAM GENERATOR

having a surface of 1570 sq. ft., is of special construction, installed as shown with the inlet and outlet headers outside of the furnace proper. No economizer is used but an air preheater of the plate type is installed above and behind the unit. Both forced and induced draft fans together with the fuel distributor are mounted on top of the furnace.

The unit is fired from all four corners of the furnace, the burners being located so that their combined action produces a turbulent spiral motion of the fuel and gases downwards through the furnace. The burners are cast iron, round nozzles, 6 in. in diameter. There are eight burners, four for each mill, arranged in two planes, four, or one in each corner to a plane. The planes are 2 ft. 6 in. apart. Air for combustion is taken, or rather is forced (due to the action of the forced draft fan delivering cold air to the preheater) from the air preheater into a rectangular duct, installed around the sides of the furnace. From this duct the heated air is delivered to the burners and to the pulverizer mills where it aids in driving the moisture from the coal to assist in pulverization.

Coal from the overhead coal bunkers is delivered to two independent feeders on the operating floor, which feed into two impact pulverizers of 5 t. capacity each in the basement. Powdered coal is drawn from the mills by two exhausters, both of which deliver to the distributor on top of the steam generator.

Coal used at the present time is Springfield district Illinois coal running about 11,500 B.t.u. per lb. (dry) with about 16 per cent ash, 45 per cent fixed carbon, 30 per cent volatile and 15 per cent moisture and 4.5 per cent sulphur.

Ash, which collects in both of the two hoppers constituting the settling chamber, is delivered to a conveyor running underneath the ash gates which in turn delivers it to ash cars running the full length of the boiler house. These cars are hauled from the plant by a gasoline locomotive.

Figure 1A is a photograph of the steam generator taken during construction to show the actual appearance of the heating surfaces before the casing was applied and before the superheater was installed. The latter can be seen lying on the floor in the foreground. The fuel is blown into the furnace at the points A.

Relay Arrangements Make Control Foolproof

The control of this unit is of exceptional interest. Except for the initial lighting of the burners the entire operation is controlled by push buttons from the main control board shown in Fig. 3. This board was designed under the supervision of Mr. Klein of the Staley Co. and is located in front of the generator on the operating floor. It has mounted on it a steam flow meter, a multipoint draft indicator, a recording steam pressure and temperature gage, a recording pyrometer, a recording and indicating CO_2 meter as well as all the control push buttons. The drum controllers for the forced and induced draft fans are mounted directly in front of this panel.

All the motors driving the various fans and mills are fitted with thermal overload relays and the mill motors, exhaust fan motors and the forced and induced draft motors are in addition fitted with definite time limit relays. The control is entirely foolproof, the relays being so set and so interlocked as to prevent any of the motors being stopped or started except in their proper order and at the proper time with respect to each other.

No part of the system can be started unless the forced and induced draft motors are operating. Once these are placed in operation by means of the push button on the control panel, the other motors driving the mills and exhausters can be started in proper sequence. When shutting down, the mill motors stop first, followed by the exhaust fans 30 sec. later; finally, the forced and induced draft motors stop 2 min. after the stopping of the exhausters. This is done to clear the furnace of all coal and combustible gases.

The generator operates at a steam pressure of 200 lb. per sq. in. gage and with 150 deg. superheat, giving a total steam temperature of 538 deg. At normal rating it will deliver 125,000 lb. of steam per hour and at maximum rating 150,000 lb. Feedwater is delivered to the boiler at 210 deg., the water entering the unit at both ends of the large drum shown in the upper right-hand corner, Fig. 1A. Steam is taken from the top of the same drum.

Based on a CO_2 content of 14 per cent, the unit is designed to handle 171,700 lb. of flue gas per hour normally and 210,500 lb. at maximum rating. Furnace gases enter the water screen at a temperature between 2000 and 2250 deg. F. and enter the induced draft fan at from 392 to 475 deg. F. Air for combustion enters the preheater at 70 deg. and is heated to from 625 to 728 deg. F.

Generator Combines Small Space with High Capacity

In considering the advantages of the steam generator as installed at the A. E. Staley Mfg. Co., it is

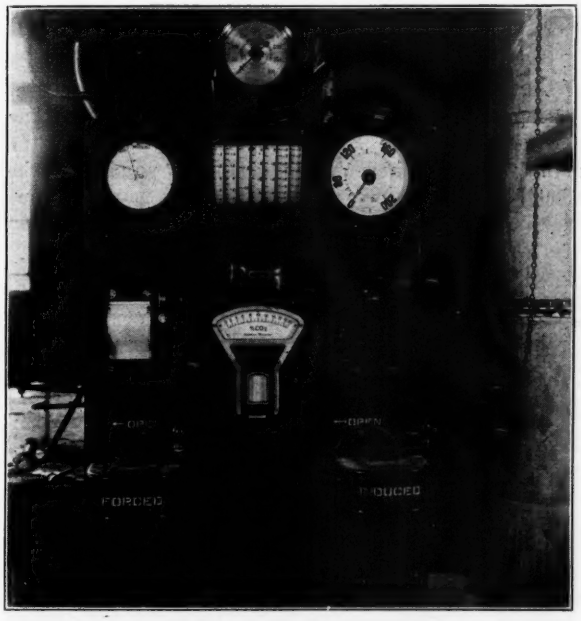


FIG. 3. THE STEAM GENERATOR IS CONTROLLED ENTIRELY FROM THIS BOARD

interesting to compare it with the ordinary boiler units in the same plant. Several years ago, an enlargement of the boiler room was necessary and at this time space was provided for six large boilers fired by means of chain grate, forced draft stokers. Boilers No. 13 and 14 were installed and space provided for four additional units to be installed when needed. These boilers (13 and 14) are strictly modern, rated at 897 hp. each, and will deliver 2000 hp. at maximum capacity. Boilers 1 to 12 are slightly smaller, being rated at 580 hp. and good for 1000 hp. maximum. The new steam generator in the same column spacing and area provided for either boiler 13 or 14 will develop 5000 hp. The generator occupies 557 sq. ft. of floor space while boilers 13 and 14 with a combined capacity less than the steam generator require 1000 sq. ft. The installation of three more steam generators of the same type makes possible a total of 20,000 hp. in a space planned for slightly less than 5000 hp. This is a distinct advantage in an industrial plant where economy of space is often necessary

As regards heating surface, the new generator has a total of 8211 sq. ft. whereas boilers 13 and 14 have 8970 sq. ft. each. In other words, from the same amount of heating surface the steam generator produces over twice as much steam.

A remarkable feature of the steam generator is its inherent flexibility of operation. Because of the entire

FIG. 4. VIEW ON 440V. BUS FLOOR

absence of brickwork in the furnace, no time need be spent in heating up large refractory surface and the generator can be put on load from "cold" in from 10 to 15 min. This same feature enables it to respond instantly to the slightest variations in load. In case repairs are necessary, the generator is cool enough 30 min. after the coal is shut off to enable a man to enter the furnace.

This generator, as has been stated, is installed in the same boiler room with the older boilers and delivers steam into the common steam mains of the plant. It is supplied with feedwater from the regular system, no special feed pumps being necessary. The water used is taken from Lake Decatur which has a normal hardness of 12 to 16 gr. per gal. Water for the entire plant, some 3,000,000 gal. daily, is treated in a settling chamber system with lime and sodium aluminate where the permanent hardness is changed to temporary hardness. Water for the boiler house about 1,000,000 gal. daily is then additionally treated in a zeolite softener where the hardness is reduced to a maximum of about 5 gr. sodium carbonate.

Entire Turbine Room Visible from Control Room

The new turbine room is a fine example of what can be accomplished in industrial power plant design by the application of practices which have been proved successful in central station work. As may be noted from the accompanying photograph, the turbine room is a

spacious hall, attractive in appearance and abundantly illuminated by a large skylight installed the full length of the room. The floor is of red square tile with black inlay and the walls are of white tile. A wainscoting of cream colored tile, with a red border at the floor line and two rows of dark blue tile at the top, runs entirely around the room. The roof is of steel and poured gypsum construction, the steel being painted a light olive green.

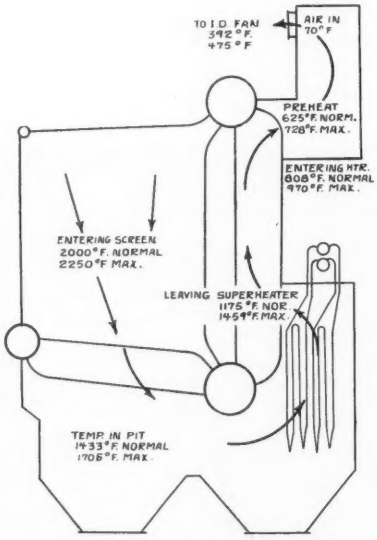


FIG. 5. DIAGRAM SHOWING TEMPERATURES IN VARIOUS PARTS OF STEAM GENERATOR

manufacturers and as soon as it is returned and installed in the new turbine room, the old turbine room will be shut down, and the remaining units moved to their new location. All turbines operate non-condensing, exhausting into a common exhaust steam main, carrying from 2 to 5 lb. pressure. This common exhaust main serves as a great reservoir of exhaust steam to which all turbines and other steam using equipment deliver and from which all low pressure steam using equipment in the factories draws.

An excellent feature of the plant is the location of the electrical control room and electrical galleries with respect to the generating room. The former are located at one end of the turbine room, with large windows so arranged that the entire turbine room is visible from any of the electrical galleries.

Electric control, switching and transformer equipment occupies one entire end of the turbine room building. Leads from the main generators pass along the ceiling of the basement directly to the main circuit breakers on either the second or fourth floor of the electrical bay depending upon whether they are 2300 or 440 v.

Ingenious Transformer Connections Solve Circuit Breaker Problem

At this point it may be well to explain that two generating voltages are used. Before the installation of the new generator, the standard voltage throughout the plant was 440 which is the generator voltage of the 1000, 1500 and 2500-kw. units. The new machine, however, is a 2300-v. unit, which not only effects a saving

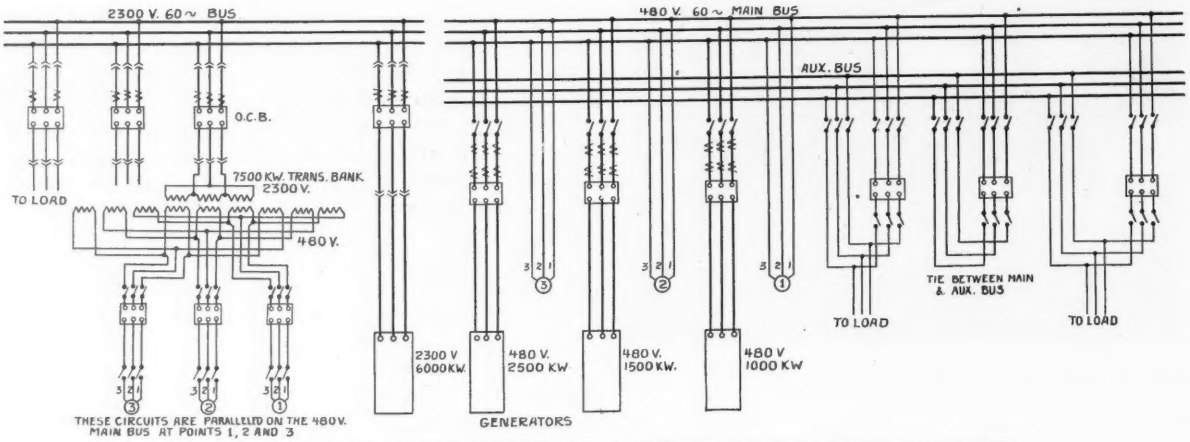


FIG. 6. SCHEMATIC DIAGRAM SHOWING ARRANGEMENT OF ELECTRICAL SYSTEM

Space is provided for four turbo-generators, one of which is installed. This is a new 6000-kw. General Electric Co. Curtis unit, consisting of a 9-stage, 3600-r.p.m., 185 lb. pressure, noncondensing turbine direct connected to a 7500-kv.a., 2300/4000-v., 60-cycle, 3-phase generator with a 37-kw., 125-v. exciter on the same shaft. Ventilating air is cooled by G. E. surface air coolers.

The foundations for the other three units are in place and will support the 1000, 1500 and 2500-kw. turbo generators now operating in the old turbine room. The 2500-kw. unit is now being overhauled by the

in copper, but also lends itself better to the large motors in the plant. To permit either the 2300-v. or the 440-v. machine to furnish power to the system of different voltage, a set of transformers is provided for tying the two systems together.

The problem involved in effecting this tie satisfactorily was solved in an ingenious manner. Because the transformer bank referred to was placed directly between two power systems, currents of high value had to be handled, especially on the 440-v. side, and it was found that the highest capacity circuit breakers (4000 amp.) which the manufacturers could furnish, were too

small for the possible currents involved on short circuit. Various methods of overcoming this limitation were considered. One suggestion was to use two or more circuit breakers in parallel, but since it is almost impossible to effect simultaneously operation of breakers in parallel, this scheme was abandoned. Air circuit breakers were also considered, but owing to the nature of the industry with the danger from dust explosion, open breakers were obviously too dangerous.

A solution to the problem was finally attained by an arrangement and connection of transformer windings, which is shown in Fig. 6. The low voltage winding of each of the three transformers constituting the tie, are divided into three equal sections. These 9 windings are then connected to form three delta connected groups, each group being connected to one of three separate oil circuit breakers. The other sides of these breakers are connected in parallel on the main 440-v. bus. The advantage of this arrangement is obvious. Since each breaker is connected to only one-third of the total transformer winding, it cannot, under any condition, be called upon to handle more than ⅓ of the total short circuit current of the bank. At the same time they are always in parallel and will pass the total current as effectively as if a single breaker were used.

FIG. 7. SHOWING METHOD OF RUNNING GENERATOR LEADS

The transformers are standard General Electric type H. 2500-kv.a. units with special windings to suit the requirements described above.

The electrical bay consists properly of five floors, the first floor containing the transformers and d.c. control equipment for the exciters and other d.c. motors. On the second floor are installed the enclosed truck type breakers for all 2300-v. service. On the floor above this, is the main control room and the chief engineer's office. The fourth floor contains the 440-v. buses and switches and, the fifth floor, which is really a monitor roof, provides for the distribution of overhead cables to factory buildings.

A photograph of the cable distribution floor is shown in Fig. 8. The excellence of this installation can be appreciated when the photograph, Fig. 8, is compared with Fig. 9 which shows a typical condition prevailing in many industrial plants. All circuits leave the power house from the point shown in Fig. 8.

Another feature of particular interest is the manner

FIG. 8. THE DISTRIBUTION FLOOR. FROM HERE CABLES RUN OVERHEAD TO VARIOUS PARTS OF THE FACTORY

in which the main generator cables are installed. Because of the large size of these cables and the large number of them to be handled, it was considered undesirable to use the open cable runways with cross arms as supports. There are a total of 30 cables leading from the generators to the electrical bay; 24 of these are 2 million cir. mil., paper core cables and 6 are 1½ million cir. mil. leads. After considering various possibilities, these cables were finally installed in fibre conduit. Each cable is placed in a separate conduit which rests upon a layer of transite laid directly upon the supporting steel. The conduits are held in place at a proper distance from each other by means of wooden spacers, as shown in Fig. 10. The conduit is in 5-ft. lengths, threaded at the ends and is supported approximately where the couplings occur. In addition to placing the cables in conduit in this manner, each group of cables from a generator is further completely enclosed in a

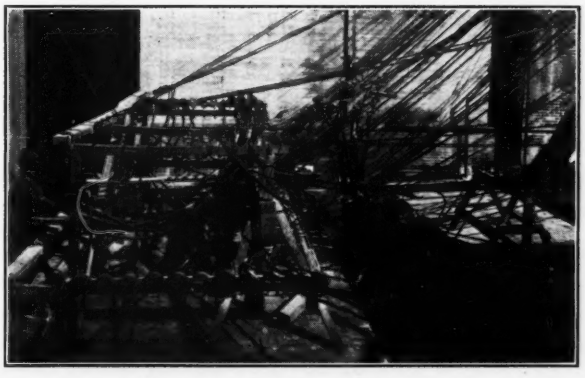


FIG. 9. A TYPICAL CONDITION PREVAILING IN MANY INDUSTRIAL PLANTS

transite casing. This not only keeps out dust but more effectively prevents trouble on the leads from one machine being communicated to an adjacent group of cables. The conduit construction extends from the generators, horizontally along the basement ceiling and then vertically up the electrical bay to the circuit breakers. There are 36 2-million cir. mil. cables, installed between the transformer bank on the lower floor and the 3 circuit breakers on the 440-v. side, with 12 cables to each switch.

All 2300-v. circuit breakers are of the enclosed truck type operated by remote control from the control room on the floor above. These are shown in Fig. 1. The 440-v. equipment, circuit breakers, and buses are of standard design supported on steel pipe framework.

There are two 440-v. buses, a main bus and an auxiliary bus. Feeders are arranged so that they may draw from either the main bus or the auxiliary bus, although normally they are supplied from the main bus. The auxiliary bus may be energized by the closure of a bus tie breaker. All oil circuit breakers are operated by remote control and any breaker may be isolated by the opening of disconnects on both sides of each unit. The main bus consists of 48 1 by 4-in. copper bars, at the center and tapering off to 16 1 by 4-in. at both ends so as to reduce the investment in copper. The auxiliary bus consists of two 1 by 4-in. bars.

The main control room is exceptionally well designed. The main generators and the tie circuit breakers are controlled from a bench board facing the turbine room so that the operator has full view of the machines he is controlling. Opposite the bench board is the vertical panel distribution board for both the 440-v. and 2300-v. circuits. Each feeder panel is provided with an integrating watthour meter and the total power output is recorded by a General Electric totalizing meter. Two power factor meters, one for each voltage, are mounted on a swinging panel at one end of the distribution board. These meters are permanently connected to the potential circuits so that when it is necessary to read them, only the current coils are connected by means of a plug and receptacle. This eliminates possibility of incorrect reading due to varying temperature conditions of the voltage coils.

A small vertical board at one end of the control room controls the station lighting and exciter circuits. For emergency lighting, a magnetic switch is provided which automatically throws a certain number of lights placed at strategic positions throughout the station, over to a storage battery circuit.

CONSTRUCTIONAL AND PERFORMANCE DATA ON STEAM GENERATOR

Furnace volume	5000 cu. ft.
Water heating surface	
To furnace radiation	1910 sq. ft.
To convection in bottom screen	1404 sq. ft.
To convection in rear bank	5036 sq. ft.
Total steam surface	8211 sq. ft.
Superheater surface	1570 sq. ft.
Air preheater surface	24,436 sq. ft.
Tube sizes and arrangement—	
Bottom screen, 6 parallel rows, 114-3 in. O.D. tubes on 12¾ and 6⅜-in. centers.	
Rear bank, 248 3-in. O.D. tubes	
31 tubes wide 4½ and 6¼-in. centers.	
8 rows deep on 5⅝-in. centers.	
Air preheater 136 elements, ½ by ½-in. spacing, 5 ft. 0 in. wide by 20 ft. 0 in. long.	

Performance Data (Designed for)

	Normal	Maximum
Evaporation, lb. per hr. actual	125,000	150,000
Evaporation, lb. per hr. equivalent	143,000	171,500
Steam pressure, lb. per sq. in. gage	200	200
Hydrostatic pressure, lb. per sq. in	352	352
Total steam temp. deg. F	538	538
Superheat	150	150
Feed water temperature, deg. F	210	210
B.t.u. liberated, net		
Per cu. ft. furnace volume	31,600	38,800
Per sq. ft. radiant surface	82,700	101,600
Overall efficiency, per cent	85	83
Fuel, lb. per hr. (dry)	14,200	17,430
Fuel, Ill. Bituminous Coal Analysis 46 per cent F.C., 32 per cent vol. 16 per cent ash, 11,500 B.t.u. per lb. dry, 6-12 per cent moisture.		
Dry flue gas, lb. per hr	164,000	201,000
Moisture in flue gas, lb. per hr	7,700	9,500
Total flue gas, lb. per hr	171,700	210,500
Total air required, lb. per hr	158,000	194,000
Based on CO_2 per cent	14	14

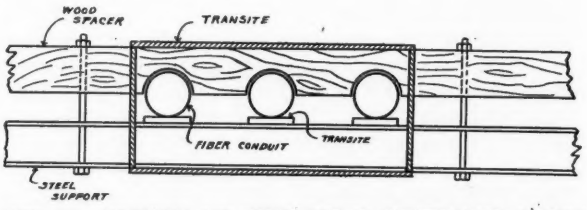


FIG. 10. METHOD OF SUPPORTING GENERATOR LEADS

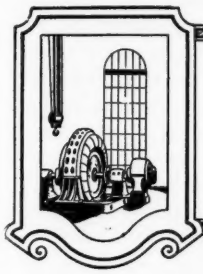
In concluding this article, we wish again to direct attention to the care and detail with which every part of the plant has been worked out and to the freedom with which the most modern principles of power plant design have been applied. There seems to be a general idea prevailing that an industrial power plant must be inherently different in its constructional features from a central station plant. The Staley plant disproves that idea. Mr. Klein, the chief engineer, is a firm believer in the applicability of central station principles to industrial plant construction and in the design of this plant he has proved his contention.

This article covers only the most important engineering features of the plant. There are many other interesting things which for lack of more space we must omit. Features such as the automatic electric elevator serving the electrical bay, for instance, have nothing to do with the direct generation of power, but they put the last finishing touch upon a plant and are well worth the expense involved in providing such equipment.

Considerable credit is due to the A. E. Staley Mfg. Co. in having the confidence and foresight to sponsor and invest their capital in such new developments as the steam generator. It is due to the close co-operation between the manufacturers and those willing to make the first installations that the ultimate success of such equipment is due.

ACCORDING TO A RECENT REPORT of the Department of Commerce, the total production of soft coal during the week ending November 26, including lignite and coal coked at the mines, is estimated at 8,838,000 net tons. Compared with the output of the preceding week this is a decrease of 1,160,000 t. Total production of anthracite during the week ending November 26 is estimated at 1,286,000 net tons as against 1,951,000 t. in the preceding week. The decrease is attributed largely to the shut down of mines in the anthracite field on Thanksgiving Day, November 24.

BETTER to watch what you are doing than to watch what the other fellow is doing.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Automatic Switching of Incoming A. C. Lines

A Description of Various Equipments Available for Automatically Controlling Service to Substations. By A. E. Anderson*

AUTOMATIC SWITCHING equipment, as defined by the title of this article has a very broad field of application. Such equipment serves as the tie between the generating station and the outgoing automatic reclosing stub feeders, which are usually rated 2300/4000 v. and applied to distribution circuits. At times this type of equipment has been used as the means for supplying power to other important loads such as railway substations, mills, theaters, hospitals, etc. In the last named applications two sources of power are available, one being used as the preferred or normal and the other, as the emergency or standby. Such applications result in greater continuity of service.

The application of various forms of automatic switching to a system is shown in the one-line diagram, Fig. 1. In this illustration the system and interconnections are made as simple as possible. It is realized that no one system would probably contain the various types of equipment illustrated therein.

In Fig. 1, power is supplied to the system by generating stations designated as No. 1 and 2. A tie line or lines connect these two stations. In the following discussion it is assumed that these lines may or may not be in service. This results in the generating stations being held in synchronism through the tie line, or they may not necessarily be in synchronism when this line is out of service. Six automatic substations are connected to this system, each of which will be discussed in order.

Balanced Power or Parallel Incoming Lines

A common form of incoming lines is the parallel or balanced power arrangement illustrated by Substation No. 1 in Fig. 1. This substation is fed from the generating station by means of two lines of practically equal impedance. Normally both breakers A and B at the generating station and substation are closed. In case of a current unbalance as caused by a fault on one line, the oil circuit breaker feeding this line from the generating station is tripped, as well as the corresponding breaker A or B at the substation. Breakers at Substation No. 1 reclose only when 3-phase voltage has been established on the incoming line for a definite time. This means that the corresponding generating station breaker must be reclosed either manually or automatically and an attempt made to re-establish service on the line. In case of short circuit conditions, only a few such attempts are made by the generating station breaker and the substation breaker therefore does not reclose. In this manner the brunt of the overload duty is thrown on the generating station breaker.

The 3-phase voltage indication for a definite time shows that the fault has been removed and that the line is clear. The time delay is used in order to permit any protective relays to operate before the substation breaker is closed. At times it also permits certain loads to be applied gradually in a step-by-step sequence. At the expiration of this timing action the substation incoming line breaker (A or B) closes and normal connections are restored, with both breakers closed.

Preferred-Emergency Incoming Lines from Synchronous Sources

This type of equipment may be considered as a modification of that just described. In view of the fact that the two incoming lines, Substation No. 2, Fig. 1, are of different impedances, enough current unbalance might be obtained to operate any protective relays—if both breakers A and B were closed for any appreciable time. Again, local conditions may require using only one incoming line as the source of power. Consequently, the load at this substation is normally supplied from one line, called the preferred line. The other line, called the emergency line, is used only in case it is in good condition and voltage has failed on the preferred line.

Figure 2 illustrates the necessary panel-mounted devices for the control of such an equipment. This panel may be used for controlling a.c. or d.c. operated oil circuit breaker mechanisms. A.c. operation is the more common and is becoming still more so. On the top section are mounted four undervoltage relays. Ordinarily two relays are used for each line, one for each of two phases.

The general sequence of operation of such an equipment is as follows: Upon the occurrence of undervoltage on any phase or phases of the preferred line, its undervoltage relays start to drop out and after a short time delay will close a set of contacts. Operation from this point on depends on the condition of the emergency line.

*Switchboard Dept., General Electric Co.

In other words its voltage conditions must be satisfactory, otherwise there is little to be gained in making a transfer.

Assuming conditions are thus far satisfactory for a transfer, a timing relay with a relatively longer setting than the undervoltage relay is placed in action. This relay (as shown at the extreme left and right at the top of the middle section, Fig. 2) is energized from the emergency line, but is controlled by the undervoltage relays on the preferred line. The timing relay is 5 to 10 seconds or over), then the preferred breaker is tripped. This tripping action is also obtained by voltage from the emergency line. As soon as the preferred breaker opens, the emergency breaker is closed. The control is so interlocked that, when a transfer is made in this direction, the preferred breaker must be open before the emergency breaker may close. The reason for this is that a fault may exist on the preferred line and, if both breakers were closed simultaneously, this fault would be reflected to the emergency line, which

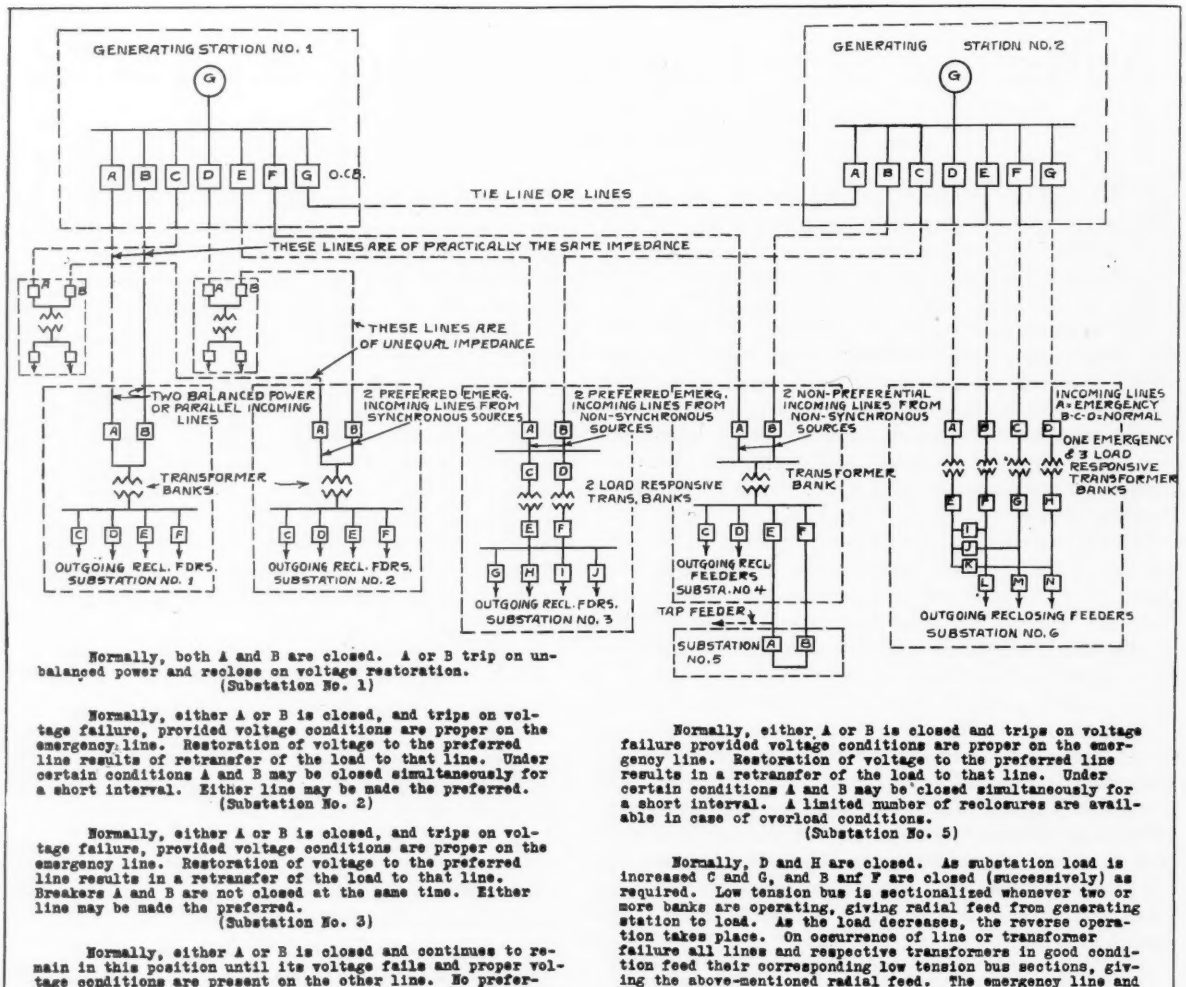

GENERATING STATION NO. 1
G
A B C D E F G O.C.B.
TIE LINE OR LINES
GENERATING STATION NO. 2
THESE LINES ARE OF PRACTICALLY THE SAME IMPEDANCE
THESE LINES ARE OF UNEQUAL IMPEDANCE
TWO BALANCED POWER OR PARALLEL INCOMING LINES
2 PREFERRED EMERG. INCOMING LINES FROM SYNCHRONOUS SOURCES
2 PREFERRED EMERG. INCOMING LINES FROM NON-SYNCHRONOUS SOURCES
2 NON-PREFERENTIAL INCOMING LINES FROM NON-SYNCHRONOUS SOURCES
INCOMING LINES A=EMERGENCY B-C-D=NORMAL
ONE EMERGENCY & 3 LOAD RESPONSIVE TRANSFORMER BANKS
TRANSFORMER BANKS
2 LOAD RESPONSIVE TRANS. BANKS
TRANSFORMER BANK
OUTGOING RECL. FDRS. SUBSTATION NO. 1
OUTGOING RECL. FDRS. SUBSTATION NO. 2
OUTGOING RECL. FDRS. SUBSTATION NO. 3
OUTGOING RECL FEEDERS SUBSTA. NO 4
TAP FEEDER
SUBSTATION NO. 5
OUTGOING RECLOSING FEEDERS SUBSTATION NO. 6
Normally, both A and B are closed. A or B trip on unbalanced power and reclose on voltage restoration. (Substation No. 1)
Normally, either A or B is closed, and trips on voltage failure, provided voltage conditions are proper on the emergency line. Restoration of voltage to the preferred line results of retransfer of the load to that line. Under certain conditions A and B may be closed simultaneously for a short interval. Either line may be made the preferred. (Substation No. 2)
Normally, either A or B is closed, and trips on voltage failure, provided voltage conditions are proper on the emergency line. Restoration of voltage to the preferred line results in a retransfer of the load to that line. Breakers A and B are not closed at the same time. Either line may be made the preferred. (Substation No. 3)
Normally, either A or B is closed and continues to remain in this position until its voltage fails and proper voltage conditions are present on the other line. No preference is given to either line under a majority of conditions. (Substation No. 4)
Normally, either A or B is closed and trips on voltage failure provided voltage conditions are proper on the emergency line. Restoration of voltage to the preferred line results in a retransfer of the load to that line. Under certain conditions A and B may be closed simultaneously for a short interval. A limited number of reclosures are available in case of overload conditions. (Substation No. 5)
Normally, D and H are closed. As substation load is increased C and G, and B anf F are closed (successively) as required. Low tension bus is sectionalized whenever two or more banks are operating, giving radial feed from generating station to load. As the load decreases, the reverse operation takes place. On occurrence of line or transformer failure all lines and respective transformers in good condition feed their corresponding low tension bus sections, giving the above-mentioned radial feed. The emergency line and bank (Breakers A and E) replace any defective line and bank. (Substation No. 6)

FIG. 1. ONE LINE DIAGRAM SHOWING TYPICAL A.C. AUTOMATIC SUBSTATIONS TOGETHER WITH CONNECTIONS BETWEEN GENERATING STATIONS AND SUBSTATIONS

used to prevent a transfer caused by momentary voltage "dips" and also to allow any protective scheme to operate and clear a fault which may cause such "dips." It has been found, as the result of a number of tests, that the ordinary oil circuit breaker mechanism does not operate fast enough to make a transfer. This results in holding in all of the so-called "instantaneous" undervoltage releases commonly used with induction motor starters. At times 50 per cent of such releases have been held in where the oil circuit breaker mechanism was purposely speeded up.

If undervoltage conditions still exist (usually from would result in a loss of substation voltage and no means of opening the preferred breaker.

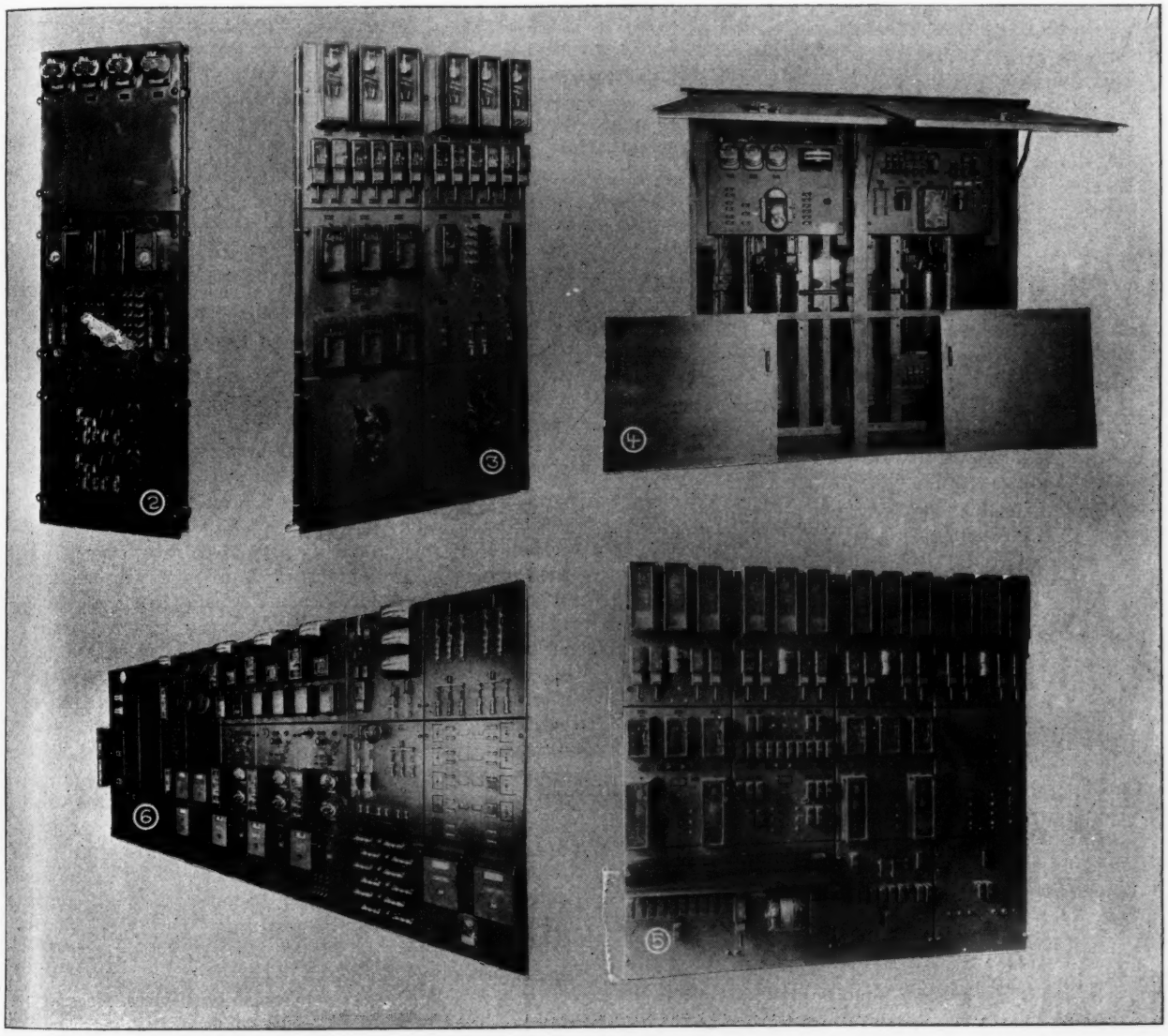
Consequently, in making the above transfer, the load is momentarily dropped. However, if voltage remains on the emergency line and also returns to the preferred line for a definite length of time, then the preferred breaker is closed after which the emergency breaker is immediately opened. This temporary overlap is so short that protective relays will not operate, and it results in a re-transfer without dropping the load.

There are a number of other conditions to be met by such an equipment. These requirements to a certain

extent account for the presence of the two relays (Fig. 2) located between the two timing relays on the middle section. Such conditions are briefly; the positions of the oil circuit breakers, the voltage conditions on their respective lines, type of oil circuit breaker mechanisms, etc. Such an equipment would probably appear at first glance to have only a few possible operating combinations from which the relays have to work and establish the proper sequence. Upon further investigation it is found that there are a number of such combinations, all of which are practical conditions and can be taken care of by proper connections or choice of devices.

An application of incoming lines of this type is shown by Substation No. 3 in Fig. 1. It will be noted that the two incoming lines may be out of synchronism if the tie line between the generating stations is out of service. Therefore, breaker A (in Substation No. 3) must be open before B can close, and vice versa. If this is not done, and the above mentioned tie line is out of service, then the incoming line equipment may tend to connect two generating stations which may be out of synchronism. The panel-mounted devices used for this purpose are also illustrated in Fig. 2.

Undervoltage conditions for a predetermined time will cause the preferred breaker to be tripped (by voltage from the emergency line) after which the emergency breaker is closed. A return of voltage to the preferred line will, after a time delay, cause the emergency breaker to be tripped and the preferred breaker to be closed. No attempt is made to go from one line to the other unless the line to which the transfer is to be made is in better condition than—or as good as—the



FIGS. 2-6. EQUIPMENT USED FOR AUTOMATIC SWITCHING OF A.C. LINES

Fig. 2. Panel mounted devices for controlling preferred-emergency incoming lines from synchronous or non-synchronous sources as well as for controlling non-preferential incoming lines. Fig. 3. Devices for controlling 2 load responsive transformer banks. Fig. 4. Combined outdoor a. c. reclosing feeder and incoming lines for 4000-v. circuit. Fig. 5. Devices for controlling 4—13,200 v. incoming lines and their respective transformer banks. Fig. 6. Devices mounted on 3 similar panels in center of this board used for automatically synchronizing 3 incoming lines with bus.

one which has been supplying power previously. If both breakers are open and voltage returns to one line, the breaker on that line will close. If both breakers are open and voltage returns to both lines the preferred breaker will be closed.

The settings of the timing relays are such that they are greater than the maximum setting of any protective relay.

Referring to Fig. 1, it can be seen that lines A and B (Substation No. 3) will be in synchronism if the tie line between the generating stations is in service. Consequently there may be times when a retransfer can be made from the emergency to the preferred line without dropping the load. Such switching can be made when proper voltage conditions exist on both lines. In order to make certain that these voltages are of the proper phase relation it is necessary to add a synchronism check relay to the devices as shown in Fig. 2. If the conditions are such that this relay does not operate, then the emergency breaker must open before the preferred breaker can close. If the conditions are satisfactory, then the preferred breaker is closed after which the emergency breaker is tripped.

Two load responsive transformer banks are also shown at Substation No. 3. One bank carries the substation load during light load periods, while the second bank is connected when the load on any one phase increases to a predetermined value. When the load on all three phases decreases to another predetermined value the second bank is disconnected.

The indication for bringing on or taking off the second bank is obtained from current transformers connected in the line. Where two or three power transformers are used, it is found advisable to parallel the current transformer secondary circuits and totalize the current on each phase. This permits the use of a fewer number of master relays with a resulting simplification of relay calibrations. If one set of relays is used for each bank it becomes necessary to provide a gap in the relay calibrations in order to avoid the need for two sets of relays calling for opposite switching action.

Differential and thermal protection are ordinarily provided. Upon failure of one bank it is immediately disconnected and locked out. The remaining bank then takes its place and no further load responsive switching is performed until the lockout relay or relays are manually reset.

Non-Preferential Incoming Lines

At times it has been found advisable to allow either incoming line to feed the load as long as proper voltage conditions exist on this line, regardless of conditions on the other line. Should voltage fail on the first line and conditions be satisfactory on the other, then the breaker on the first line would be tripped and the breaker on the other would be closed. The other line would continue to feed power to the load regardless of a return of voltage to the first line. In view of the fact that a breaker can remain closed as long as voltage remains on its line and no preference is given under a majority of conditions, such forms of incoming lines are called "non-preferential." The controlling devices are practically the same as those shown in Fig. 2, except that no transfer switch is necessary in order to establish preference.

As one breaker is always open before the other can close, these equipments may be connected to synchronous or non-synchronous sources. (Substation No. 4, Fig. 1.)

Combined Reclosing and Preferred-Emergency Incoming Lines

It frequently happens that two preferred-emergency incoming lines supply one outgoing feeder. Overcurrent protection is provided, to trip whichever breaker is closed. If overload conditions persist, a certain total number of reclosures is permitted after which the equipment is locked out. Substation No. 5, Fig. 1, illustrates the application of such equipment. Figure 4 shows an outdoor unit for such service.

Undervoltage conditions are taken care of in practically the same manner as the above-mentioned preferred-emergency units. The combination equipment can be used for synchronous or non-synchronous sources, and can also be made non-preferential.

Automatic Substations Supplied by More than Two Incoming Lines

Substation No. 6, Fig. 1, illustrates the application of an automatic station that is supplied by four incoming lines with their respective transformer banks. Line A and its associated transformer are emergency units and take the place of any line or transformers that have failed. Lines B, C and D are the normal sources of power.

Normally line D and its associated transformer feed the low tension bus sections which are now tied together. Whenever sufficient load demand occurs, the second bank is brought on and the first bank carries only its section of the bus with its connected outgoing feeders. Continued load demand brings on the third bank with the corresponding connections. The low tension bus is now completely sectionalized and each incoming line feeds its share of the outgoing feeders direct from the generating source. This results in radial or stub feed direct from the source to the load which requires only a simple relay protective scheme at the generating station end of the lines.

If any line or bank fails, it is taken out of service automatically and replaced by the emergency line. The remaining lines (in good condition) feed their share of the load direct, as in the case of switching under normal conditions.

Figure 5 illustrates the controlling devices necessary for the above operation. The relays make the proper set-up, after which the panel-mounted drum controller completes the required switching operation. The use of a drum controller for such equipment greatly decreases the number of contacts necessary on the relays and also results in a positive sequence of operation. With an equipment of this type it is possible to find at least 12 operating positions or combinations in which the drum controller takes part.

In general, there are two conditions under which an incoming line is automatically synchronized with the bus. One condition is where the system is already tied together at some other point. This means that the two

voltages, at the open breaker terminals, are stationary with respect to each other, but may have a certain phase displacement caused by circuit or load conditions. Such a condition may occur at Substation No. 3 in Fig. 1, when the tie line between the two generating stations is in service.

Assuming this tie line to be out of service, then the two voltages, at the open breaker terminals, may be rotating with respect to each other at a frequency equal to the frequency difference between the two generating stations. The equipment in Substation No. 3 has no control over the governors in either generating station; therefore the closing operation of the breaker is determined by other factors; namely, (1), the frequency differential must be less than a certain value and (2) the breaker closing impulse must be given at a time sufficiently ahead of synchronism to enable the breaker to be closed when the point of synchronism is reached—in other words, at "12 o'clock."

Such operation is obtained by the devices shown in Fig. 6. The calibration of the synchronizing relays for the two different operating conditions is such that one is inoperative under conditions where the other functions.

Procedure in Starting Up a New Generator

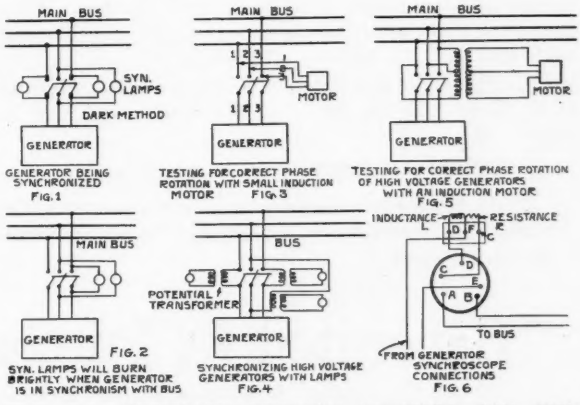
PART III.* FINAL INSPECTION, STARTING UP, SYNCHRONIZING METHODS OF PHASING OUT. BY MARIN PHILLIPS

ASSUMING THAT the generator has been thoroughly dried out by any of the methods described in the previous articles,* the machine is ready to be started. See that all equipment used in starting has been cleared away and admit enough driving power to the prime mover to start the generator turning over slowly. Inspect the lubricating system and determine the condition of the bearings every few minutes while the machine is turning over slowly. If no abnormal conditions arise, the generator is then brought to normal speed and kept at that speed from ½ to 1 hr. If after an hour's run nothing unusual occurs, the field current can be applied gradually, starting with all the resistance in the rheostat in circuit. The field strength is brought up slowly by cautiously increasing the field current and making careful inspections until the voltage has built up to normal. During the time the voltage is increasing, use your eyes for observing the performance, your nose for the odor of burning insulation and your ears to detect unusual noises that may develop. If hot insulation is found, kill the field at once and set out to locate and remedy the trouble.

Before two alternating current generators can be paralleled, two conditions must be fulfilled. First the frequency must be the same and second, the phase rotations must be the same. There are several methods available to indicate when the incoming generator is in synchronism with the generator with which it is desired to parallel it. First the lamp method can be connected in two different ways. When connected as indicated in Fig. 1, the lamps will be dark when the generator is in synchronism with the bus bars. Figure 2 shows the lamps so connected that they will burn bright when synchronism is reached. Either method can be used, although the dark method is most generally used, as it is considered easier to tell when the lamps are totally dark than when at the period of greatest brilliancy.

In phasing out a new generator, a lamp bank should be connected to each phase.

It is necessary to provide lamps that will stand twice the generator voltage. For a 220-v. generator, use two 220-v. or four 110-v. lamps in series, for when the generator has full voltage and is 180 deg. out of phase with the bus, twice generator voltage will be impressed on the lamps. In case the maximum brilliancy method of synchronizing is desired, it will be better to phase out the generator with the lamps connected as in Fig. 1, and when it is known to be phased out and all connections permanently made, two of the lamp connections can be reversed as in Fig. 2. Another method of phasing out a generator is to use an induction motor. Figure 3 shows the procedure to follow. Mark the leads on the bus side of the switch 1, 2 and 3, and mark the motor leads 1, 2 and 3. Any small motor of correct voltage, phase and frequency can be used. Connect the leads of the motor marked 1, 2 and 3 on to the corresponding leads at top of switch from the bus and note the direction of rotation. Next start the generator, bring it up to speed and raise the voltage to normal. Now connect the motor leads 1, 2 and 3, to the bottom corresponding leads on the generator side of the switch and again note the direction of rotation. If the motor runs in the same direction that it did with the motor leads connected to the top or bus side, then the generator is phased out correctly and is ready to be synchronized and paralleled on the bus. But in case it runs in an opposite direction, the assumed generator connections to the switch are incorrect and two of the



FIGS. 1-6. DIAGRAMS SHOWING METHODS FOR SYNCHRONIZING AND PHASING OUT GENERATORS

*This is the last of a series of three articles by the author. The first two appeared in the Oct. 15 and Nov. 15, 1927 issues respectively.

leads will have to be reversed in order to get it in phase with the bus. After the leads are reversed, make another test in order to make sure that the connections are properly made. The connections shown in Figs. 1, 2 and 3 are for low voltage generators such as 220, 440 and 550 v. With the 2300-v. generator discussed in this article, it will be necessary to use potential transformers as shown in Fig. 4, to step the voltage down to say 110 or 220 v. for the synchronizing lamps. Figure 5 shows the connections for phasing out the generator with an induction motor.

The other method used for synchronizing is by means of the synchroscope. During the last few years, generator switchboard panels have been equipped with synchroscopes which have replaced the old lamp method of synchronizing, although most synchroscopes have lamps connected into the circuit which will always serve as a check on the synchroscope. Figure 6 shows the connections of a well known synchroscope. The indicating pointer has no springs or weights for returning it to a certain position as there are in other switchboard instruments. Instead, it is free to revolve through a complete revolution. When the generator to be synchronized is being brought up to speed, the pointer will rotate in a counter clockwise direction, indicating that its synchronism speed is below that of the bus. When the speed of the alternator is so that it is in synchronism with the bus, the pointer will stand on zero, that is, pointing straight upward, indicating that the generator is in phase with the bus and the main switch can be closed.

Additional Remarks on Synchronizing

1. On alternators whose voltage is greater than 550, use potential transformers for the synchronizing lamps and synchroscopes.

2. In an emergency, voltmeters can be used for synchronizing. Because of their high resistance, they can be connected between the generators safely. When the generator is in phase with the bus, the pointer will be on zero and when they are out of phase it will swing forward and backward on the scale.

3. When three-phase alternators are to be synchronized, it is necessary to provide lamps in two phases at least. If lamps are connected in only one phase, it is possible to obtain a partial short circuit by having the other two phases crossed.

4. If possible use the lamp method for obtaining the correct phase rotation and check it with an induction motor.

5. In the case of two direct current generators operating in parallel, the amount of load that each generator is to carry can be regulated by increasing or decreasing the field excitation. On an alternating current generator, the load can not be regulated by changing the rheostat. Such procedure only increases or decreases the wattless current, which will tend to demagnetize the field. When alternating current generators are running in parallel, the division of load must be made by adjusting the speeds of the prime movers. When making load adjustments, watch the watt-meter and adjust the fields so that the ammeter readings will be kept as low as possible. By watching the wattmeter it will be found that the ammeter readings can be varied over a wide range, by increasing and decreasing the field excitation without changing the output as registered by the wattmeter.

As the amount of heating developed in the winding depends on the amount of current flowing in them, it is desirable and a good policy to keep it as small as it is possible to do so without lowering the working voltage.

Generated vs. Purchased Electrical Energy

School Buildings Secure Power and Light More Economically from Their Own Plant Than from Utility Company. By H. O. Swoboda*

SOME six years ago the School District of Altoona, Pa., W. F. Eberle, president, and W. N. Decker, secretary, realized that it would be advantageous to combine the individual heating plants of four of its school buildings into one and at the same time to utilize this steam for generating all the electric current required in the buildings. The accompanying plan of the buildings shows that four schools, the Senior and Junior High as well as the Lincoln and Emerson Grammar Schools are located on three adjoining city blocks covering a plot not larger than 710 by 562 ft. and that the power plant could be located thereon. The connection between the power plant and the various buildings was established by means of tunnels especially built for the purpose.

The original plant was built in 1922-23 to supply the Senior high school and the two Grammar schools only. To these, the Junior high school was added in 1923 by increasing the equipment of the power plant. Since that time, it has been operated in such manner that it supplied all four schools during the periods of largest demand, viz., during school hours. During the off-peak periods over night as well as on Sundays and during the summer vacation, the Penn Central Light and Power Co. has supplied all power and light but no steam. During cold spells in winter time, however, the steam plant has been operated day and night.

With the new addition to the Senior high school which is now under construction, another increase to the power plant is unavoidable and the question arose as to whether the power plant, during the four years of its existence, has actually saved the school district any money or whether its cost of operation, so far as power and light is concerned, exceeded the amount for which the electric light and power could have been purchased.

To determine this, the investigation resulting in a report, of which this is an excerpt, was authorized so that the Board could either provide the necessary addition to the power plant or secure from the utility company the necessary power and light for the new build-

*H. O. Swoboda, Inc., Pittsburgh, Pa.

ing or eventually for all buildings. While making the investigation, it was also considered desirable to determine the actual first cost of the entire plant and the percentages of operating costs of the power plant with which each of the four school buildings should be charged. Due to the carefully kept records, such an analysis at this late date was possible and has been carried out accordingly.

Capital Investment

Occupying a plot 50 by 120 ft., the power plant consists of a one-story brick building with an asphaltum coated concrete roof, containing three 374-hp. B. & W. steam boilers with all accessories as well as three 200-kv.a. General Electric turbo-generators with switchboard and wiring. Tunnels connect the plant with the four schools as shown on the plan of buildings.

The capital invested in the plant was found to be as follows:

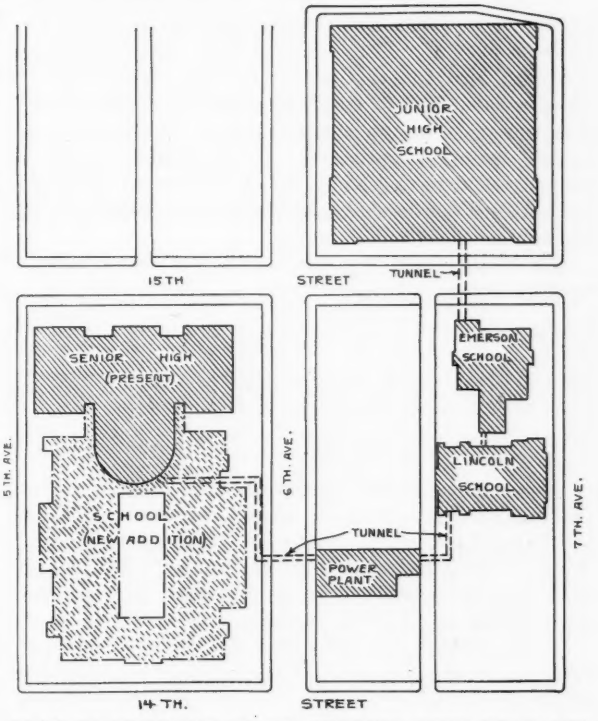
Power Plant plot		$ 12,000
Building and tunnels		107,398
Heating Plant equipment consisting of 3 374-hp. B. & W. boilers complete with stacks	$ 64,782	
Water Supply Equipment, comprising surge tank, air compressor, centrifugal pump together with piping to the water well; 50,000-gal. steel water tank with tower and concrete foundation; feedwater treating equipment: boiler feedwater heater; meter and boiler feedwater pumps; blow-off tank; electrically-driven vacuum pump	22,510	
Fuel Equipment, comprising coal and ash handling plant, including skip hoist, crusher, motors and control system; Coxe stokers with engines and tools; turbine-driven blowers; economizers; soot blowers; instruments	100,562	
Tunnels with pipe lines including steam and water piping to all schools. Alterations in the old heating plants of the various schools; condensate pumps in school buildings; receiver tanks in power plant	54,060	
		$241,914
Generating Plant Equipment consisting of 3 200-kw., 250-kv.a., 3600-r.p.m., 2300-v., 3-phase, 60-cycle G. E. turbo-generators arranged to operate at 175 lb. steam pressure, complete with traveling crane, capacity 10 tons; switchboard; transformers; all necessary wiring		38,688
Total first cost		$400,000

This capital was provided out of six bond issues totaling $4,700,000 between the years 1921 and 1927, of which, by the end of the year 1927, $400,000 had been redeemed. Of the redeemed amount, $76,000 was applied to the power plant, leaving a net investment of $324,000. This redemption was decided upon without considering the proper percentage of depreciation, for the reason that the first cost of the power plant had not heretofore been established accurately. Had that been known and if annually 4 per cent on the buildings and 5 per cent on the equipment had been applied, not allowing any depreciation on the power plant plot, then the depreciation would have been $83,660 instead of $76,000 and the present actual value of the plant would be on the books as $316,340 in place of $324,000. In view of the fact that all repairs and renewals for maintaining the plant in first class condition were charged to operating costs, this discrepancy should be considered of no consequence; it can be taken care of without difficulty by an adjustment during the present year.

As already stated, the investigation was undertaken not only for determining the cost of operating the power plant but also to distribute that cost over the accounts for the four school buildings in accordance with their individual requirements. This made it necessary to determine the requirements for each building. A careful survey showed the following connected heating equipment:

Name of School 1	Sq. ft. Direct Radiation 2	Power House Share 3	Total Share of Each School 4
Senior High	33,153	152	33,305
Junior High	87,883	404	88,287
Emerson	2,808	13	2,821
Lincoln	22,665	105	22,770
Total	146,509	674	147,183

In the above, column 1 gives the names of the school buildings; column 2 the total heating surface in each school expressed in square feet of direct radiation, including the actual direct radiation and the mechanical equipment as an equivalent number of square feet of



PLAN OF BUILDINGS TO BE SUPPLIED WITH HEAT AND POWER

direct radiation; column 3 gives the heating surface in the power plant expressed in square feet of direct radiation as apportioned to the different schools and column 4 the total of columns 2 and 3.

Live steam consumed in the various schools and by the accessories in the power house is not included in these amounts.

Maximum demand on the boilers, which these equipments may make in zero weather, based on general experience, would be in pounds of steam per hour, for the Senior high school, 9611 lb.; Junior high school, 18,722 lb.; Emerson school, 702 lb.; Lincoln school, 3115 lb.; power plant, 168 lb.; total, 32,318 lb.

Adding to this amount a consumption of 3253 lb. of live steam per hour, the maximum demand on the boilers in zero weather would be 34,571 lb. per hour which is equivalent to 1000 boiler horsepower.

Hourly steam requirements during the various months of the year were also calculated and found to be as follows:

	Total lb. of Steam	Average Demand Boiler Hp.
July	.....	...
August	.....	...
September	1,616	47
October	7,315	212
November	14,159	410
December	18,370	593
January	20,391	668
February	19,912	643
March	15,710	508
April	9,435	273
May	4,128	119
June	.....	...

Based on these figures and assuming that the requirements for maintaining a temperature of 70 deg. F. in the buildings for 9 hr. a day, 25 days a month and a temperature of 40 deg. F. during the remaining time, the steam requirements would be 31,132,860 lb. per year.

In order to verify the correctness of this calculation, it was checked with actual operating figures taken for the year 1926-27. These figures show that 3538 t. of coal were used and that on the average each pound of coal generated 5 lb. of steam, or a total of 35,380,000 lb. of steam per year as compared with 31,132,860 estimated. As either figure may be considered correct, a compromise figure of 33,257,000 lb. of steam per year was assumed for heating and service requirements and was applied in all calculations.

Total connected electric equipment in kilowatts capacity was as follows:

Name of School	Connected Load, Kw.	Power House Share	Total Share of Each School
1	2	3	4
Senior High	195.4	27.4	222.8
Junior High	282.7	39.8	322.5
Emerson	6.9	1.0	7.9
Lincoln	27.0	3.8	30.8
Total	512.0	72.0	584.0

These figures are based on an actual survey and tabulated in identically the same manner as those for the total connected heating equipment, showing that there is a total connected load of 584 kw., split up into 387.3 kw. for power, 171.5 kw. for light, 25.2 kw. for electric heating and miscellaneous.

Study of the possible energy requirements was not necessary, because the meters in the plant recorded the actual consumption. But a careful investigation was made to determine whether it was ever necessary to make steam solely for the generation of electric energy. It was found that the heating equipment required more steam than was necessary for power and light, except for a small quantity of 28,220 lb. during the month of September.

Present Operating Data

Records kept by the School District disclose in detail the operating costs from 1922 to 1927 consisting of pay roll, fuel, repairs, renewals and miscellaneous expenses as well as electric energy purchased from the utility company. The various figures were embodied in the report and a summary is given herewith.

Description of Expense	1922-23	1923-24	1924-25	1925-26	1926-27
Pay Roll	$ 4,935.00	$ 7,685.00	$ 8,850.00	$10,050.00	$ 9,780.00
Heating Plant.	6,800.00	1,920.00	1,920.00	1,920.00	1,920.00
Generating Plant	10,895.55	11,699.02	12,536.23	13,262.34	12,542.42
Repairs and renewals to heating plant	1,721.49	1,636.81	1,265.54	2,180.78	2,244.40
Generating plant	1,019.24	382.83	257.23	333.43	256.56
Total operating costs	$25,371.28	$23,323.66	$24,829.00	$27,746.55	$26,743.38
Capital charges	31,215.50	35,769.00	35,046.00	34,326.00	33,602.00
Elec. energy purchased		1,580.12	2,690.42	3,377.84	3,873.94
Total power plant costs.	$	$60,672.78	$62,565.42	$65,450.39	$64,219.32

Unit costs for steam and electricity were found to be:

	Steam per 1000 lb.	Electricity per kw-hr.
Net operating costs	$0.72	$0.007
Interest	0.34	0.012
Depreciation	0.41	0.014
Total	$1.47	$0.033

For electric energy purchased from the utility company during the four years of operation the cost was $0.045, $0.042, $0.040 and $0.044 per kw-hr., respectively.

Summary of Cost Comparison

Based on the information collected and the various calculations made, the percentages of operating costs of the power plant were distributed over the various school buildings as follows:

Name of school	Cost of steam	Cost of electricity	Share of each school Total	Per cent
Sr. High	$14,436.38	$ 8,670.60	$23,106.98	36
Jr. High	29,360.74	5,057.90	34,418.64	53
Emerson	994.86	144.50	1,139.36	2
Lincoln	4,976.34	578.00	5,554.34	9
Total	$49,768.32	$14,451.00	$64,219.32	100

Values given in the above table are based on the year 1926-27 for the cost of heating, and on the mean of the years 1925-26 and 1926-27 for the cost of electric energy.

If all electric energy had been purchased and the operation of the generating plant discontinued, using the boilers merely for steam heating, the electric energy would have cost $6786.23 for 323,912 kw-hr., or $0.021 per kw-hr. Interest on discarded equipment would be $3819.00 and depreciation $4581.50. These, plus the electric energy costs, would equal $15,186.73, or a total yearly cost for steam and electric energy of $64,955.05. This would still be $1.47 per 1000 lb. of steam, but the cost of electric energy would be $0.047 per kw-hr. as against an average of $0.0446 under present conditions.

If no electric energy had been purchased and the present power plant operated continuously to meet all needs, the cost would be : net operation cost at present, $26,743.38; additional fuel expense, 522 tons at $3.50, or $1827; added repairs on steam plant, $550.42, and on generating plant, $154. Total operating cost, $29,274.80. Capital charges would be unchanged, $33,602. The cost of electric energy purchased would be eliminated. Total yearly cost for the power plant would be $62,876.80 which would be $1.47 per 1000 lb. of steam and $0.04 per kw-hr.

Senior High School Addition

Estimated requirements for the new addition are 425 boiler hp. for heating and 140 kw. for power and light. By operating the boilers at 150 per cent of their rating instead of 100 per cent, the reserve capacity would be increased from 12 per cent to 18 per cent and, by operating the turbo-generators at their rated pressure of 175 lb. steam instead of at 165 lb., their reserve capacity would be decreased from 38 per cent to 31 per cent.

The operating costs, under the present schedule, buying current on off-peak periods, would then become as follows:

	Steam	Electricity	Total
Present net operating costs	$24,566.82	$ 2,176.56	$26,743.38
Additional pay roll	none	none	none
Additional fuel, 1106 tons, $3.50 each	3,871.00	none	3,871.00
Additional repairs and renewals	450.00	51.30	501.30
Total operating costs	$28,887.82	$ 2,227.86	$31,115.68
Capital charges	26,533.50	9,208.00	35,741.50
Total plant charges	$55,421.32	$11,435.86	$66,857.18
Electric energy purchased	none	4,921.40	4,921.40
Probable total power costs	$55,421.32	$16,357.26	$71,778.58

Conclusions from the Investigation

As a result of the investigation, the following facts are disclosed:

The operating costs of the power plant for 1926-1927 amounted to $64,219.32, distributed as follows:

Steam for heating, $49,768.32; electric energy generated, $10,577.06; electric energy purchased, $3,873.94.

Reduced to unit costs, this is:

Heating steam per 1000 lb., $1.47; generated electricity per kw-hr., 3.3c; purchased electricity per kw-hr., 4.4c.

Distribution of costs among the various schools has been previously shown.

If all electric energy were purchased from the public utility company, the total power plant costs on the present schedule would be $64,955.05, which would give unit costs of $1.47 per 1000 lb. of steam for heating and 4.7c per kw-hr. for electric energy.

If no electric energy were purchased and the power plant operated continuously, the total cost would be $62,876.80, giving unit costs of $1.47 per 1000 lb. of steam for heating, and 4c per kw-hr. for electric energy.

According to the basis previously given, the energy consumption for each of the four schools during the year 1926-27 was as follows:

	Steam in lb.	Electricity kw-hr.
Senior High	8,270,700	170,857
Junior High	16,472,000	101,345
Emerson	593,050 }	14,560
Lincoln	2,661,600 }	

Operating the power plant in its present condition, the comparison of the various methods shows that if no electric energy were purchased, the cost would be $62,876.80. Operating by the present method, purchasing electricity for off-peak periods, the cost would be $64,219.32, and operating the plant only for steam, purchasing all electric energy, the cost would be $64,955.05.

After completion of the addition to the Senior High School, the relative costs are estimated as follows:

For continuous plant operation with no electrical energy purchased, $69,727.65; for present method of operation, $71,778.58; purchasing all electricity, $73,515.32. This gives unit costs as shown below for the three different methods:

	Operated continuously	Present mode	Electric energy purchased
Steam	$1.23	$1.36	$1.23
Electricity generated	0.032	0.025	.....
Electricity purchased	.....	0.039	0.039

Saving by generating electrical energy with the present mode of operation over purchasing it all is 2.6 per cent, which, by continuous operation, purchasing no electrical energy, can be increased to 4.7 per cent, and probably increased to 5 per cent for continuous operation after the Senior High School addition is in service.

In addition to savings pointed out, it should be remembered that after 20 yr. from 1922, the plant will have earned and repaid the entire indebtedness of $400,000 so that, from that time on, capital charges will be eliminated and the cost of electrical energy reduced to about one-half present amounts.

If electrical energy were purchased, the cost after 20 yr. would continue at the same rate as now.

Unit costs for steam and electricity would be as follows:

	1000 lb. of steam	Kilowatt-hour Generated	Kilowatt-hour Purchased
Operating costs	$0.64	$0.0048	.....
Interest	0.27	0.0090	.....
Depreciation	0.32	0.0107	.....
Total costs	$1.23	$0.0245	$0.039

If all electric energy were purchased, the total costs would increase to $73,515.32 and if the power plant were operated continuously to meet all needs, purchasing no electric energy, the total costs would be reduced to $69,727.65.

Additional Boiler

If another 374-hp. boiler were installed, the capital charges and total operating costs would be increased proportionately and the unit costs under the present operating schedule would be as follows:

	1000 lb. of steam	Kilowatt-hour Generated	Kilowatt-hour Purchased
Operating costs	$0.64	$0.0048	.....
Interest	0.33	0.0090	.....
Depreciation	0.39	0.0107	.....
Total costs	$1.36	$0.0245	$0.039

If all electric energy were purchased, the cost of steam would remain the same and the electric energy would cost $0.039. If all electric energy were generated, the cost of steam would drop to $1.33 per 1000 lb. and the electric energy would cost $0.0323.

Boulder Dam and Umatilla Hearings Under Way

House Committee Will Probably Report Colorado River Bill. Electric Power Industry Not Fighting Umatilla Project. By Wingrove Bathon*

NEW HEARINGS have begun in Washington on both the Boulder Dam bill for flood control, irrigation and electric power on the Colorado River and the bills involving the protection and development of the Umatilla Rapids in the Columbia River. These hearings have been going on simultaneously in both the House and Senate.

Most of the hearings on the Boulder Dam bill, which are before the House Committee on Irrigation and Reclamation, have been devoted to an attempt, on the surface, to compose the differences of opinion and claims of the seven states involved in the so-called Colorado River compact—Wyoming, Colorado, Utah, New Mexico, Nevada, California and Arizona.

As this is written no agreement among the states as to the protection of their various rights is in sight. But under the surface, in connection with these hearings on the Boulder Dam bill, attempts are being made to bring about a compromise between those who are for the bill and those who are against it, which would bring the measure in line with established Government policies

*Washington Representative of Power Plant Engineering.

in dealing with power resources. The municipality of Los Angeles, as well as private companies in Southern California, are potential purchasers of the power to be generated by the dam, if and when built, provided the power can be sold at a price which compares favorably with power from other sources.

Such a compromise would more than likely take the form of proposed amendments to the bill which would satisfy all parties in interest. Nothing has been settled in that respect as this is written. The question involved here is whether the power is to be sold (if the dam is built) on the basis of the cost of the entire project, including flood control and reclamation features, or on the basis of its value when it is ready for delivery.

The bill proposes to appropriate $125,000,000, although engineering opinion is that the large Boulder Dam project will cost not less than $200,000,000. The claim of the Reclamation Service is that the project will finance itself, on the basis that power could be sold at the switchboard at 3 mills per kw-hr. To this cost must be added the cost of transmission to a market 250 mi. distant, as well as resultant energy losses in transmission. Engineers who oppose this project say this would bring the cost of the power at Los Angeles to 5.7 mills per kw-hr., which is higher than the present cost of steam power delivered at that point. The whole question of steam power generation, and the recent advances in that art, must be taken under consideration.

It is estimated that the Boulder Dam project would require a ten-year period for its construction. If so, steam plants must be built to supply the increased demands of that period, aggregating about 1,000,000 hp. The electric power companies in the territory under consideration are now building such steam generating stations. There has been so much reduction in steam power costs recently, notably with the new mercury process, at Hartford, Connecticut, that to compete with such power as that, Boulder Dam power would have to be sold at the switchboard at one-third of the estimated price or at 1.0 mill per kw-hr. instead of the price of 3.0 mills per kw-hr. as estimated by the Reclamation Service.

Irrespective of what the House Committee reports, Martin B. Madden, Chairman of the House Appropriations Committee, has said that his appropriation plans and policies do not include an appropriation of $125,000,000 or more for Boulder Dam at this session of Congress. It is, therefore, problematical what the House will do with the bill; and its fate is even still more problematical in the Senate.

The hearings on the bill to protect and develop the Umatilla Rapids in the Columbia River are taking place before the Committee on Irrigation and Reclamation on the Senate side and the Committee on Irrigation and Reclamation on the House side. This bill involves an appropriation of $45,000,000. Some of the economic and engineering facts in regard to it were set forth in Power Plant Engineering for January 15, page 142, quoted from a letter from the Director of the Budget to the Senate Committee on Irrigation and Reclamation which showed that the appropriation at the time the letter was written during the last session of Congress was not approved by the President and the Director of the Budget. A change may come, however, in the appropriation phase of the Umatilla situation. The bill is fashioned after the Boulder Canyon bill, except that no flood control is involved. It is proposed to construct in the Columbia River, under this bill, a dam and incidental works at an elevation (of water) 310.5 ft. high at a point near Pendleton, Oregon. When the impounding site is filled, the dam would be 57 ft. high. The amount of commercial power supposed to be available at this dam when built is estimated as varying from 80,000 hp. for the maximum pumpage project to 350,000 hp. for the minimum pumpage project. These are estimates of power deliverable to the electric power transmission line 90 per cent of the time. With storage provision (and such storage is obtainable at a relatively low cost, according to the report on the bill), the output of commercial power could be increased to 500,000 hp. or more, depending on the amount of storage provided. The concluding sentence of this section of the report is significant and attention was drawn to it during the hearings. It is as follows: "To the extent that there was a market for this power the net revenue from power sales would operate as a credit to the pumping projects." The fact is the market for this power is nebulous at the present time and for some time to come. It is proposed to canalize the river and make it capable of navigation from the proposed dam up to where the Snake River empties into the Columbia River. It is claimed that much commerce will result, flowing down from Idaho, Montana, Eastern Oregon and Washington. Reclamation is involved over a large tract. It was stated before the Committee that the whole of the Pacific Northwest is interested in the passage of the Umatilla bill and endorsements were produced from chambers of commerce, boards of trade and many other business organizations in that section of the country.

Senator Johnson and others who have assumed that the power companies would necessarily be against the passage of the Umatilla bill have a surprise in store for them. It may be that they will be able to read it in these printed words for the first time. The power companies are not necessarily opposed to the passage of this bill. The philosophy underlying that statement might be expressed by pointing out that on many streams of the country there are, on one side of the stream, the Government ownership principle, and on the other side of the stream the private ownership principle. The trouble is that all these streams will not fall in either one or the other category and there are sites part of the usefulness of which is for proper governmental purposes, such as navigation, irrigation and so forth. It is not conceivable that any private organization or that any private capital would develop certain sites of that sort like the Umatilla Rapids on the Columbia River. The power purpose alone will not sustain the investment, and will not for many years. If the irrigation purposes, combined with the navigation purposes, are sufficient to justify the public expenditure, then it is not reasonable to assume that power developed as a by-product should be thrown away. On the contrary, it should be used, paid for and made to bear its proper appropriate part in the carrying of the development. Under such circumstances, the Government is put into the power business, whether it wants to be there or not.

Counterflow and Uniflow Non-Condensing Engine Economies

In the July 15 issue, A. J. Nicholas gravely makes the statement that a single-cylinder Corliss counterflow engine is more economical than a unaflow engine. He comes to this conclusion by taking the steam rate of a non-releasing-gear Corliss engine of 21 lb. (steam and exhaust conditions have not been mentioned) and opines that, if the engine had been equipped with steam-heated heads, it would have been more economical than a unaflow. Under any non-condensing saturated steam condition 21 lb. for a Corliss engine is lower than is usually expected of this type of engine. He concludes that the reason why the Corliss engine must be more economical than the unaflow is the fact that the unaflow has more super-saturation.

In the September 1 issue, A. F. Sheehan, chief engineer of a large plant in Springfield, Mass., who had operated unaflow engines of both large clearance and small clearance types, called Mr. Nicholas' attention to the fact that he had probably compared his revised Corliss engine economy with the economy of a large-clearance, two-valve unaflow engine and not with a small-clearance unaflow engine having auxiliary exhaust valves properly placed, namely, away from the ends of the cylinder. He furthermore called attention to the fact that the Corliss engine, if it could have obtained the economy Mr. Nicholas thought it could, was a much larger engine than the unaflow. He raised the point that the poppet valves which are used on most unaflow engines would remain tight longer than the valves of a Corliss. He could also have stated that, in comparing the alleged full load economy of the Corliss with the full load economy of the large-clearance unaflow, he was taking the worst possible economical load condition for the large-clearance unaflow.

In his reply, which was published in the Dec. 1 issue, Mr. Nicholas admitted that the unaflow economy he had referred to in his former letter was that of a large-clearance engine without auxiliary exhaust valves and he challenged Mr. Sheehan's statement that a small-clearance unaflow with auxiliary valves was more economical than a large-clearance unaflow without exhaust valves. He stated that Professor Stumpf in his book on The Una-flow Steam Engine "clearly recognized the limitations of the unaflow engine for non-condensing operation," whereas the very chapter he referred to proved the reverse.

Mr. Nicholas refers to a chapter devoted to the relative advantages and disadvantages of clearance pockets and double-seated auxiliary exhaust valves placed in the ends of the cylinder of a condensing unaflow engine to allow it to operate non-condensing if the vacuum were lost. Professor Stumpf explains that these double-seated valves in their end location will require more clearance when the engine is operating condensing and will, therefore, increase the condensing steam rate, which is, of course, absolutely true and, for long condensing operation he recommends hand-controlled clearance pockets, stating, "For short periods of non-condensing service even a considerable increase in steam consumption due

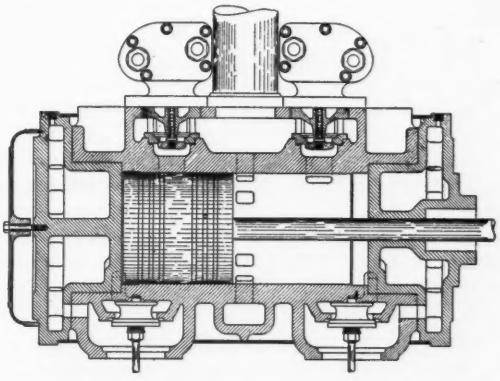


FIG. 1. CROSS-SECTION OF A UNIVERSAL UNAFLOW CYLINDER SHOWING EXHAUST VALVES LOCATED AWAY FROM ENDS OF CYLINDER

to the additional clearance could be tolerated." Here he plainly states by inference that, operating non-condensing, an engine equipped with auxiliary exhaust valves will provide greater economy than if equipped with additional clearance.

Mr. Nicholas, to prove his case that a non-condensing unaflow engine with clearance pockets was more economical than one with properly located auxiliary exhaust valves, quotes Professor Stumpf as saying something absolutely opposite to what he actually did say. In his own language, Mr. Nicholas quotes Professor Stumpf as follows: "The corresponding increase with auxiliary exhaust valves, superheated steam and *non-condensing* operation was 0.264 lb. for each per cent of clearance." What Professor Stumpf actually said was, "For 1 per cent increase in clearance volume, an additional steam consumption of 0.12 kg. (0.264 lb.) per i.hp-hr. may be expected"; and this paragraph referred to the *condensing* operation of a unaflow engine equipped with auxiliary exhaust valves.

The point that Professor Stumpf was trying to bring out was that double-seated auxiliary exhaust valves located at the ends of the cylinder of a *condensing* unaflow engine, and to be used only for non-condensing operation, would increase the steam consumption of the una-

flow engine *when operating condensing* by reason of the additional clearance.

Again Mr. Nicholas misquoted Professor Stumpf when he says, "Yet for long periods of non-condensing operation, as in winter running, he (meaning Stumpf) recommends the use of auxiliary exhaust valves in preference to clearance spaces. This in spite of the considerable increase in the steam consumption as shown above." What Professor Stumpf actually said in his book was exactly the opposite. ". . . while, on the other hand, for short periods of non-condensing service (referring to a condensing unaflow equipped with clearance pockets instead of auxiliary exhaust valves for non-condensing operation), even a considerable increase in

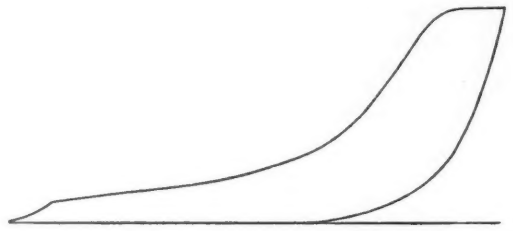


FIG. 2. INDICATOR CARD TAKEN FROM UNIVERSAL UNAFLOW ENGINE SHOWING DELAY OF COMPRESSION TO THE PROPER POINT

steam consumption due to additional clearance can be tolerated," and "for long periods of non-condensing operation, as for instance, during the winter, single-beat auxiliary exhaust valves are preferable to additional clearance."

Again quoting from Mr. Nicholas' article: "If, as Professor Stumpf shows, an engine with clearance space gives better economy than when equipped with auxiliary exhaust valves, how is it possible to obtain a horsepower on 18.5 lb. for the latter with saturated steam when published results for the former seldom if ever show less than 20 lb.?" The chapter in Stumpf's book to which Mr. Nicholas was referring was one of several devoted to steam engine losses and was headed "Additional Clearance Space." It showed that Professor Stumpf recognized the baneful effects of clearance and the chapter was devoted entirely to methods to minimize it. It will be obvious to most readers that on a non-condensing unaflow engine either one or the other method indicated must be used to prevent the compression from exceeding the initial pressure in a unaflow cylinder when operating non-condensing.

It will be seen, therefore, that Mr. Nicholas has misquoted his authority several times to challenge Mr. Sheehan's statement that a small-clearance non-condensing unaflow engine is more economical than one equipped with large clearances.

Mr. Nicholas doubts that the steam rate of 18.5 lb. per i.hp.-hr., which is the rate Mr. Sheehan took for a "Universal Unaflow" engine (i.e., one having auxiliary exhaust valves properly located), can be obtained with a steam pressure of 150 lb. saturated and atmospheric exhaust. He thinks it should be nearer 20. We expect, on every "Universal Unaflow" engine of 250 hp. capacity and above, to obtain better rates than 18.5, a typical test of a 21 by 24-in. "Universal Unaflow" engine, with 150 lb. of steam pressure saturated, atmospheric exhaust, showing the following rates:

Load	1/4	1/2	3/4	4/4
Steam rate	18.39	17.74	17.58	17.7

The penalty for non-fulfillment of the guarantees was several thousand dollars a pound of steam per i.hp.-hr. and the purchaser had his own engineers on the test. which, naturally, was carefully conducted. These economies are not unusual and have been equalled by many "Universal Unaflow" engines that have been tested under these conditions.

Did any Corliss engine ever obtain any one of the following results in lb. steam per i.hp-hr., all of which were obtained on one "universal Unaflow" engine built for the American Locomotive Co. and tested in our plant before shipment? All of these results were obtained without any change in the adjustments.

Non-condensing, 132 lb. steam, saturated	17.9
Non-condensing, 165 lb. steam, saturated	16.8
Non-condensing, 165 lb. steam, 101 deg. F. superheat	14.0
Non-condensing, 165 lb. steam, 138 deg. F. superheat	13.6
Condensing, 135 lb. steam, saturated	13.2
Condensing, 165 lb. steam, saturated	12.9
Condensing, 165 lb. steam, 98 deg. F. superheat	10.6
Condensing, 165 lb. steam, 135 deg. F. superheat	10.2

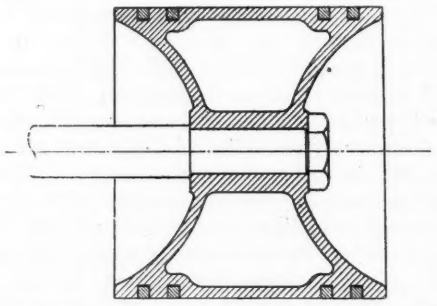


FIG. 3. PISTON OF A TWO-VALVE OR LARGE CLEARANCE NON-CONDENSING UNAFLOW ENGINE CUPPED TO OBTAIN REQUIRED CLEARANCE. IN CONDENSING ENGINES OF THIS CLASS THE CLEARANCE, INSTEAD OF BEING IN THE PISTON, WOULD HAVE TO BE IN THE HEAD AND CONTROLLED BY CLEARANCE POCKET VALVES WHICH WOULD KEEP THE CLEARANCE SPACE CLOSED WHILE OPERATING CONDENSING AND OPEN WHEN RUNNING NON-CONDENSING

Will any Corliss engine ever maintain its original economy for years as will an engine equipped with properly designed poppet valves? Everyone knows it will not.

We have built unaflow engines of both the large-clearance and small-clearance type. We have conducted in our shops exactly 761 economy tests and during this period exactly 177 field economy or acceptance tests have been conducted, or a total of 938. We are sure that no type of steam engine that has ever been built has been given so many economy tests as have been conducted on the "Universal Unaflow," the results of which, of course, have helped us to improve the later engines.

It is a pretty well-established fact that a well-designed unaflow engine is more economical than even a compound Corliss engine, either condensing or non-condensing, under the varying loads which obtain in most power plants, to say nothing of its superiority over the single-cylinder Corliss type. This is especially true when comparing the kw-hr. economies.

If a non-condensing unaflow engine were equipped with exhaust valves that were placed at the ends of the cylinder and if these valves were of such design that they were leaking and could not be ground tight, because it is impossible to duplicate the operating conditions at the time of grinding, then that type of unaflow would probably not be as economical as a Corliss engine and we happen to know of two cases where such types of unaflow engines replaced Corliss engines with the result that the boiler load was increased to such an extent that the unaflow engines were removed and the Corliss engines put back on the job.

Where a non-condensing unaflow engine, having tight exhaust valves, which are located away from the ends of the cylinder, can be placed alongside of a Corliss engine and the builders take the major portion of their pay in the savings effected, it goes to prove that the design of the auxiliary exhaust valves and their location add greatly to the economy of this type of engine.

Results of our tests on non-condensing unaflow engines equipped with auxiliary exhaust valves as compared with tests on engines of the same sizes not so equipped but having large clearance, have allowed us to make contracts whereby part of our pay is taken in the savings effected against the large-clearance unaflow engine in the same plant; and one test showed a saving of 6 lb. of steam per i.hp-hr. and 10 lb. per kw-hr.

Erie, Pa. A. D. SKINNER,
President, Skinner Engine Co.

Diesel Power Growing in Importance

HOW OFTEN writers on industrial power matters confine themselves to steam power and to purchased electricity, overlooking the important place that the modern Diesel engine holds in the field of moderate size prime movers! The Diesel engine has attained much renown in the marine field, but in stationary service its light has been "hid under a bushel."

To many engineers it will be a distinct surprise to learn that the latest U. S. Census reports show that in the size range between 100 and 500 hp. more stationary oil engines were manufactured in the year 1925 than reciprocating steam engines and steam turbines combined. Even in sizes as small as 50 hp. and as large as 1000 hp., the production of oil engines is by no means insignificant compared with steam equipment, as reference to the table herewith will show. These engines were installed in all parts of the country, not only in the Middle West near the oil fields, but also in the East and even in large cities close to superpower central stations. No study of the power problem of the small industry is complete unless the examination includes oil engine power as well as steam and purchased current.

Take for example the following editorial comment in your Jan. 15 issue on Professor Thomas N. Carver's article, "Is the Small Factory Doomed?"

Another and extremely important factor in the conduct of the small industry is that of power supply. Where the processes of the industry are such as to justify the use of considerable exhaust steam for process work, the industry, whether large or small, can often afford to make its own power. Where such process steam demands do not obtain, the central station can in most cases supply power more cheaply than the industry can make it. The various principles by which the power problems of various types of industries can be worked out have been treated from time to time by the various power plant magazines and provide a never-ending topic of discussion, since each individual case must be decided on its own merits. It must be recognized, however, that the large industry no longer possesses the great advantage of cheap power that formed one of its strongest supports in years past."

Where the demands for process steam are not such as to justify a steam power plant, the small factory seeking cheap power has recourse not only to central station current, but also to an oil engine plant of its own. Diesel power in many cases is much cheaper than purchased electricity, and the fact that it is cheap even in small plants is another significant reason why the small industry is no longer handicapped by expensive power.

TABLE SHOWING PRODUCTION OF STATIONARY OIL ENGINES, RECIPROCATING STEAM ENGINES AND STEAM TURBINES IN THE UNITED STATES DURING 1925

Size Range, rated capacity	50 to 99 hp.	100 to 499 hp.	500 to 999 hp.	Total 50 to 999 hp.	Oil Engine Percentage of total
Oil Engines	789	873	43	1705	50
Steam Engines, reciprocating	701	241	74	1016	30
Steam Turbines	275	355	46	676	20

New York City. EDGAR J. KATES.

Always Heat Parts Into Which You Pour Babbit

I WAS ASTONISHED at W. F. Schaphorst's note, page 149 of the January 15 issue. From this I must conclude that sometimes in American shops babbit is poured into bearings without heating them.

It is absolutely wrong, not only from the point of view of safety, to pour molten babbit into a cold bearing, but mainly because of the quality of the bearing which will be considerably higher if the cast iron or steel of the bearing will be heated to the temperature of the molten babbit and cooling of the bearing after pouring will follow slowly and uniformly. Only with these conditions will babbit adhere properly.

I followed this rule for about 15 yr. of my practice in Russia and know exactly that best machine works in Russia observed this rule very carefully.

Corona, S. D. N. KASANTZEFF.

Vibration Cured by Weighting Machine Parts

TROUBLESOME vibration was experienced in a motor generator set from the date of installation in a substation of a mid-west public utility company. At different times manufacturer's representatives came and inspected the machine, made various tests for alinement, and reported everything in perfect condition, but still the vibration persisted. After a lapse of a few months another representative was called in. His examination developed a grounded field, two coils shorted in the arma-

ture and a slight misalinement in the coupling faces. In his estimation this was enough to find wrong with any machine and he fully expected the unit to run like the proverbial sewing machine; however, no decrease in the rate of vibration was noted and the manufacturer's representative returned home much perplexed.

One of the company's operating engineers came to the conclusion that since the machine was in perfect alinement and balance, vibration must be due to the design of the foundation. Apparently he had been reading in the technical press that the design of a foundation must be as carefully worked out as that of the rotating element. His investigation led to the discovery that the natural period of vibration of the rather high and hollow pedestal bearings was very nearly that of shaft and armature. In order to break up this harmonious condition between the two elements, he conceived the idea of pouring the hollow pedestal bearings full of concrete; this proved perfectly successful, as vibration was entirely eliminated.

Experiences in the steam turbine field confirm this theory that often undue vibration may be traced to a poorly designed foundation as a cause.

Columbus, Georgia. J. JACOBS.

Use Wheel-Cutter for Water Gage Glasses

WATER GAGE GLASSES may best be cut by means of a wheel glass cutter mounted upon a metal rod with an adjustable stop to be set against one end of the tube so that the cutting wheel may be rotated around the tube at the point where it is to be cut off.

If a special tube-cutter, as described above, is not at hand, use an ordinary wheel cutter, nail a strip of wood upon a bit of board and place another bit of wood as an end stop for the tube and so arranged that when the glass cutter is placed against the end of the strip of wood, the length of tube from cutter to end-stop, will be exactly the length of tube required. In cutting hold the cutter against the tube, rotate the tube slowly and the cutter will do its work.

When there is no glass cutter, tack another strip of wood upon the board, place the glass tube between the wood strips and with an ordinary hacksaw, saw the soft "lead-glass" tube at the desired point.

Some engineers have the knack of cutting a water gage glass evenly and squarely, with a bit of string and a drop of cold water. The string, wet with gasoline, turpentine or kerosene oil, is twisted once around the tube at the place where it is to be cut off. It is then ignited and as soon as the oil burns off, a wetted finger is touched to the hot place in the tube, which cracks at once.

Indianapolis, Ind. JAMES F. HOBART.

Coating Affects Pipe and Chimney Friction

WHEN A PIPE becomes encrusted with scale, or after its interior is coated with slime, it makes no difference whether the pipe is made of cast iron, steel, brass or gold. It is logical that the coefficient of friction must be the same after the pipe is once coated. Before the surface is fully coated it is true that there is a difference, but where coating occurs the coefficient of friction of the coating must be considered and not the coefficient of friction of the metal. Yet in many formulas the material or metal is specified by authors rather than the coating.

The same applies to chimneys. After the interior of a chimney is once coated with soot all chimneys become alike so far as friction is concerned whether they are made of brick, concrete or steel. Yet we commonly find formulas that designate different coefficients of friction for the various materials. In using such formulas, allowance should be made for the effect of the coating, if any exists.

Newark, N. J. W. F. SCHAPHORST.

Rivet from Fuse Plug Serves Emergency

WHEN THEY are most needed small soft rivets are often mighty scarce and hard to find in a pinch. The writer recently needing some rivets in an emergency,

FUSE PLUGS SERVE AS SOURCE FOR SMALL SOFT RIVETS

discovered that by cracking an old fuse plug, the small contact button or point at the bottom served as a practical and satisfactory small rivet for the job.

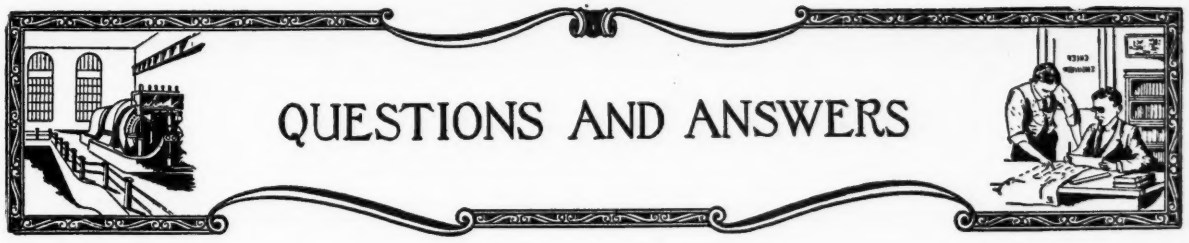
Missouri Valley, Iowa. FRANK W. BENTLEY, JR.

Drumming of Boiler Stopped by Steam Jets

MANY POWER PLANT men throughout the country have been puzzled by drumming in a boiler. I am employed in a plant where there are two 600-hp. water-tube boilers. These boilers drummed so badly at times that it was almost impossible to stay in the boiler room. The boilers were fired by natural draft traveling grates. We overcame the trouble by placing a ½-in. steam pipe perforated with 1/6-in. holes under the top part of the grate just inside of the coal gate and allowing the steam to flow up through the coal bed. This simple experiment stopped the drumming.

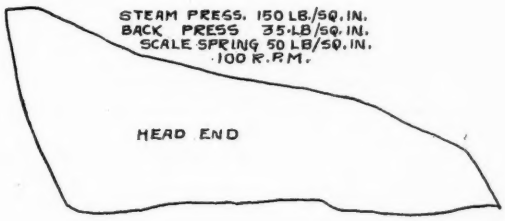
It would be of interest to hear how others have overcome this trouble.

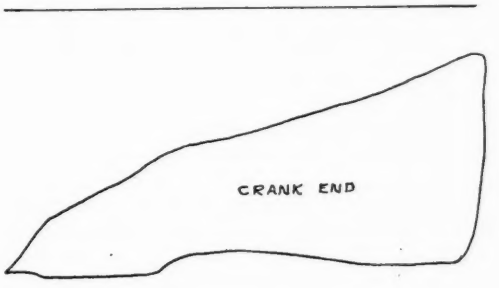
Muncie, Ill. OSCAR B. WOODS.



Cards for Criticism

CARDS HEREWITH were taken from a 14 by 18-in. balanced slide valve engine. There is about $\frac{5}{16}$-in. lead at both ends when the engine is on dead center; is this





WHAT IS THE MATTER WITH THESE CARDS?

too much lead for the head end? What is wrong with the crank end? The eccentric is set about 115 deg. ahead of the crank. Engine runs under. At 90 deg. it pounds. What causes this pound?

Oconto Falls, Wis. W. J. M.

Criticism of these cards by our readers is requested. —EDITOR.

Steam Plant Operation

WILL YOU answer the following questions:

1. If you had a cross compound Corliss engine running condensing and you have a vacuum of three or four inches on the receiver, what would you look out for?

2. If you had a lubricator with both pipe connections connected to the l.p. cylinder, would this lubricator work with a vacuum on the l.p. cylinder?

Paterson, N. J. E. F. W.

A. 1. Under the circumstances it would be very unusual to have a vacuum of three or four inches in the receiver of a compound engine. This pressure can be raised by throwing more work on the high pressure cylinder and reducing that of the low pressure cylinder by decreasing the point of cutoff in the low pressure cylinder.

If there is about 3 in. of vacuum in the receiver, the indicator card taken from the high pressure cylinder would have a large loop.

2. If you have forced feed the cylinder would be lubricated to some extent but not properly. In order to obtain proper lubrication, a check valve must be placed between the discharge of the oil pump and the inlet of the cylinder.

If your arrangement is a hydrostatic one, which we believe it is, there are hydrostatic lubricators in the market that will operate properly under the conditions imposed. In this case, steam does not have anything to do with the operation of the lubricator except that it enters the condenser on the top and becomes water which, being heavier than oil, forces the latter to the top and thence to the proper cylinder feeds.

Inertia Governor vs. Centrifugal Governor

IN AN EXAMINATION for third class engineer's license the following question, which I could not answer, was asked:

Which would you prefer for closest regulation on a riding cutoff valve, a centrifugal or an inertia governor? Why?

Worcester, Mass. C. J. L.

A. An inertia governor, because it is more sensitive and responds more quickly to change of load. If the centrifugal governor is a throttling one and the inertia governor of the shaft variety as is usually the case, the action of the latter will be quicker than that of the former because it acts directly on the amount of steam port opening while the throttling governor simply changes the pressure of the entering steam.

Are "Automatic Injectors" Automatic?

WHAT IS an "automatic injector"?

Are there any injectors in the market that automatically start to operate when the water gets low in the boiler? W. C. K.

A. So-called "automatic injectors" function by the movement by hand of only one lever. They are not truly automatic.

We know of no injector that will automatically start itself.

EDITORIAL COMMENT

A Mark for the Industrial Plant

In the industrial field standards of operation, maintenance and supervision have not been worked out to any extent and the engineer in each industrial plant is often left free to follow his own inclinations.

Of recent years industry as a whole has been slowly beginning to realize the importance of power and the power supply with the result that the power plant is not always felt to be too technical for supervision. The management is beginning to realize that proper supervision can bolster up a poor engineer and improve a good one.

Unfortunately standards of comparison are difficult if not impossible to set up. What may be considered excellent results when judged by former standards in one plant, might be considered medium in another plant.

For instance, a new power plant in any industry might show a cut in unit costs of fifty per cent over costs of the old plant just abandoned and still be operating very inefficiently when compared to a neighboring plant of the same type. Plant, size, type and operation must be considered and fuel economy is not the only item involved. A central station of different class may be designed to generate a kilowatt-hour on 12,500 B.t.u., 16,000 B.t.u. or 25,000 B.t.u., the object being to get the cheapest production considering not only fuel but labor, maintenance and investment as well. It would not be fair to say that the 25,000 B.t.u. station was not as well designed and operated as the 12,500 B.t.u. station in spite of its much higher fuel charge.

It is for the purpose of helping set up standards for the industrial plant that we present the detailed costs of the Pittsburgh Plate Glass Company's Milwaukee power plant over a period of years. The new plant practically cut their yearly power costs in half and by close application to operation and supervision, these results have been gradually improved in the subsequent two years' operation.

Their system is simple. The operating department deals with, and reports directly to, the accounting department and instruments are so tied in that they must be maintained in operating order. Supervision is maintained by the engineering department and lapse from efficient operation is immediately noted from the reports and instrument records and the operating department called upon to explain them.

Testing and Design of Bleeder Turbines

Extraction from large turbines is now almost universal practice. Many purchasers specify that the casing shall have a certain number of bleed points and also require that guarantees be made on operation with no bleeding.

Naturally the manufacturer will design and proportion his blading for the guarantee conditions of non-bleeding operation. In actual practice with extraction, therefore, the pressure distribution inside the turbine is upset by lowering the pressure at the bleed stage and at all stages subsequent to the bleed point, resulting in a lower internal efficiency for these sections of the turbine than would be the case if the blading and nozzles were designed for most efficient operation with bleeding.

This loss persists through the whole operating life of the turbine and while it is not large, it warrants a design based on operation with bleeding even though this arrangement may present difficulties in testing or may not give as high efficiency with no bleeding.

Few turbines have been definitely designed for operation with bleeding. One of these few is the new 20,000-kw. unit No. 3 at the Moores Park station in the city of Lansing, Michigan, which was purchased on a definite guarantee with bleeding and was designed for the actual operating conditions.

Complete tests were made and the results compared directly with the guarantees covered in the specifications. At every point the guarantees were exceeded by a considerable margin. Because of the scarcity of test data on large extraction units, complete test data have been given covering not only the turbine but the heaters and condensers as well so that engineers can study the actual effect of varying load conditions on pressures and temperatures in different parts of the cycle.

Difficulties of High Pressure Operation

Many of the difficulties predicted for 1200 to 1400-lb. operation have failed to materialize but this fact did not prevent or minimize the importance of many unexpected difficulties that did arise.

At Lakeside station the major difficulties came in connection with feedwater. Although supposedly pure make-up was used, condenser leakage, undetected through careful tests, supplied sufficient scale to cause boiler tube failures. No sooner had this difficulty been corrected by reducing the condenser leakage than active corrosion set in.

Correcting this by feedwater treatment and reducing the oxygen content of the feedwater resulted in a decrease from capacity and efficiency of the 1200-lb. turbine by about 30 per cent in less than two days' time. Material carried over from the boiler coated the blades of the turbine with a white deposit which, although it could be washed off with water made continuous operation impossible. All these difficulties were corrected and practicability of the 1200-lb. system proven beyond doubt.

Details of the first 11-months' operation of high pressure operation at Lakeside were given in a paper presented before the Institute of Fuel in London by John Anderson. The paper, abstracted in this issue, shows that Lakeside has successfully pioneered another important development. The frank admission, in the paper, of the difficulties encountered and the remedies used should do much to advance the cause of higher pressures. At first, we may be inclined to regret that Mr. Anderson's paper was not delivered in this country. It is probable, however, that no better means of acquainting Europe with power plant development methods in this country could have been pursued. The paper has had wide foreign circulation and has aroused a great deal of discussion. The "interchange of information" is a large factor in explaining the rapid development of the power industry in this country and the business-like way in which operating difficulties are overcome.

We are sure that any disadvantage which might be brought out due to the limited circulation of a foreign paper in this country will be more than made up by the improvement in international relations and a closer cooperation of the engineering societies and power industries, which is bound to come as a result of the paper.

Off Duty

"What!" exclaimed the young music student who had entertained us during the evening, "Do you mean to tell me that you don't like the violin?"

"Exactly," I replied, amused at his genuine horror, "The violin irritates me—makes me nervous—"

"But the violin is the most beautiful of all musical instruments," insisted my young friend. "Everybody admits that."

And there you have it. Everybody admits it; to doubt it is to invite opprobrium.

One of the outstanding differences between human beings and lower animals lies in what may be termed our trained reactions to stimulus. We do things not necessarily because we reason them out or because of our inherent desires but because we have been trained to do them. The greater our degree of civilization, perhaps, the more strong this forced reaction is. Primitive man had little convention and acted largely on the impulses of his emotions. When he was hungry, he ate, provided he could get food, but judged by Emily Post, his table manners were atrocious.

Civilized man behaves differently. When he is hungry, he indulges in a complex process called dining beset with many rules and forms, to all of which he must adhere. If he is warm, he doesn't necessarily remove his coat—it may not be the correct thing to do. An Englishman, particularly, wouldn't think of appearing at a certain social function with a red tie, however much he might desire to do so. Such things simply aren't done.

For the benefit of society, a certain amount of this adherence to form is desirable, particularly as it governs polite conduct towards individuals. But when our environment is such that we develop trained reactions which function at the cost of our intellect, civilization impedes its own progress.

The theory that the violin is the most beautiful musical instrument is in the same category with the belief that the skyscraper is an undesirable form of architecture, and that grand opera is necessarily enjoyable. These things, like religion, are matters of faith, not reason. We have been brought up to regard these things as such so that in time we come to believe them. In classical music, we are taught that a composition by Wagner, Bach, Handel or other of the old masters is beautiful and, regardless of the quality of the voices or the character of the accompaniment, people will sit through an hour of discord and racket and enjoy it. In the visual arts, the same is true. People will regard with profound admiration the discolored, weather-beaten canvas of a so-called great master and absolutely ignore a thing of sheer beauty hanging beside it, but painted by an obscure though able artist. Instead of admiring a picture because it appeals to their inherent sense of beauty, they attempt to reconcile it to all sorts of foolish rules about psychology of form and perspective which the poor artist himself probably never even heard of. Some pictures, like some musical compositions, violate every rule of form, color, tone and rhythm ever devised, yet are strangely beautiful. If a man selected his wife by rules there would be no need of divorce courts, nor of preachers either.

In all this I do not presume to belittle the ability of the great masters in any of the arts. From a technical standpoint a musical composition or a painting may be admirable and to a technician hold tremendous interest because of its difficulty of execution, but as a thing of beauty to the layman it is a miserable failure. A complex mathematical solution may be a thing of beauty to the mathematician who understands the meaning of the symbols, but to the average person this same string of integral signs and Greek exponents presents as much appeal as a violin solo would to a carp.

Blind acceptance of facts, even if they be correct, is not knowledge nor is it understanding—it is merely memory, and memory is no particular trait of the human animal. Memory exists to greater or less degree in all living things. In man it is highly developed, and in certain branches of human thought he substitutes it for reason. He unprotestingly accepts what is supposed to be correct. In religion, a man is a Methodist because his parents were Methodists, or he is a Roman Catholic because his parents are Catholic. In music he is taught that certain forms of music are beautiful, so as he grows up, in spite of any inner feelings to the contrary, he accepts these forms. He comes to believe that the violin is the perfect instrument notwithstanding the fact that it takes 24 first violins to balance one first flute, one first oboe and one first clarinet in a modern orchestra.

However, whether the fiddle has reached a state of perfection or not is not our concern here. Our plea here is for greater exercise of our reasoning powers—a little serious thinking about the things we say we believe, and a more sincere indulgence in our *inherent* sense of beauty. Merely to state that the fiddle is perfect is arrant nonsense. No one has enough positive knowledge on the subject to say that it is. Any expression of opinion on the matter is a statement of faith, pure and simple, and not of knowledge actually possessed.

Latest Power Plant Practice

COMPLETE EXHIBIT OF POWER PLANT EQUIPMENT AND DISCUSSION OF POWER PLANT PROBLEMS AND ECONOMICS BY EXPERTS

ARRANGEMENTS are completed for the largest exhibit of power plant equipment ever seen in the Middle West and for the finest program on power plant practice which has been given before any society. Exhibits will be arranged in the Coliseum, the main building and north and south halls being used with booth numbers as follows:

Booth Numbers 1-235: Main Hall.
Booth Numbers 300-343: South Hall.
Booth Numbers 400-472: North Hall.

The exhibit will open at noon, February 14, and will be open every day from noon until 10:30 p. m. up

HOTEL STEVENS, WHERE MIDWEST POWER CONFERENCE WILL BE HELD

to Saturday night. The Coliseum is reached by Wabash Avenue or State Street surface carlines or by south side elevated trains to the 12th St. Station or the south side busses on Michigan Avenue pass within one block.

CONFERENCE PROGRAM

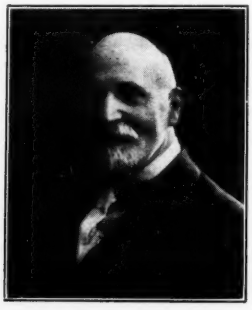
Conference meetings will be held in the Hotel Stevens, Michigan Ave. and 8th St., the registration opening at 8:30 a. m. on February 14.

The first session will be at 10:30 a. m. with address of welcome by Sewell Avery, president of the Commercial Club of Chicago, followed by an address by Major Rufus W. Putnam, Chairman of the Power Conference. At 11, Glenn Frank, president of the University of Wisconsin, will speak on Power, the Background of Today's Civilization.

In the afternoon a general session will be held at 2 o'clock, the topic being Power Accomplishments in Factory and Home. The first paper will be by W. A. Durgin, Director of Public Relations of the Commonwealth Edison Co., on America's Part in the Romance of Power. The second address, by Mrs. J. D. Sherman, president of the General Federation of Women's Club, will be on Drudgery Banished from the Home. The third address, by Burke Corcoran, Secretary of the Electric Association of Chicago, will be on How to Make the Burden Bearer Bear the Burden.

For Wednesday the 15th, the morning session will start at 9:30 on the general topic of the Relation of Power Development to Flood Control and other River Problems. Addresses will be given by Gen. Edgar Jadwin of Washington on Flood Control Problems on the Mississippi System; by D. W. Mead of Madison, Wis., on Problems of Storage for Flood Control and for Power Development; by Colonel William Kelly, of Buffalo, on Irrigation Flood Control and Power Development Problems on the Colorado River; by Major G. E. Edgerton, chief engineer of the Federal Power Commission on Status of Hydroelectric Development from the Viewpoint of the Federal Power Commission.

RUFUS W. PUTNAM



ALEX DOW

In the afternoon at 2 o'clock the same general subject will be continued, addresses being given by Major L. H. Watkins on The Tennessee River Survey; by E. A. Forward, Consulting Engineer of Montreal, on Navigation and Power Development on the St. Lawrence River; by F. A. Allner, General Superintendent of the Pennsylvania Water and Power Co. on Combined Use of Water and Steam Power; by H. A. Hageman, Chief Hydraulic Engineer of Stone & Webster on Progress and Trend in Hydraulic Power Development.

Wednesday evening the annual banquet will be held at the Hotel Stevens, starting at 7 o'clock. The speaker will be Rufus C. Dawes, on a topic of his own choosing, but related to power achievement.

Thursday morning's session will start at 9:45 on the topic of Economics of Power Stations, with addresses by Alex Dow, president of the Detroit Edison Co. and president of the American Society of Mechanical Engineers, on Capital Costs with Relation to Economy of Central Stations; by George A. Orrok, Consulting Engineer of New York City on High Pressure Operation; by Thomas E. Murray, Consulting Engineer of New York on the Trend and Development in Steam Generation.

At 1 o'clock a luncheon symposium has been arranged dealing with power transmission problems. The speakers

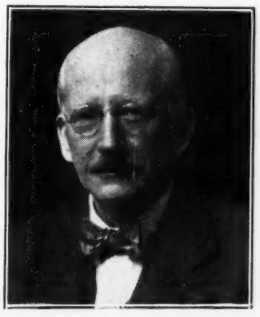
will be H. B. Gear of the Commonwealth Edison Co. on Power Transmission by High Voltage Cables; H. W. Eales of the H. M. Byllesby Co. on Overhead Transmissions; A. C. Montieth of the Westinghouse Electric & Manufacturing Co. on Developments in Apparatus for Power Transmission Systems; Wallace S. Clark of the General Electric Co. on Some Causes of Failures in Impregnated Paper Insulated Lead Sheathed Cables.

For the afternoon an inspection trip has been arranged to the Sewage Treatment Plant of the Sanitary District of Chicago, located on McCormick Drive at Niles. Transportation facilities will be provided free, and guides will be furnished at the plant to explain the equipment and operation. It is the largest plant of its kind in the country and embodies all branches of power engineering.

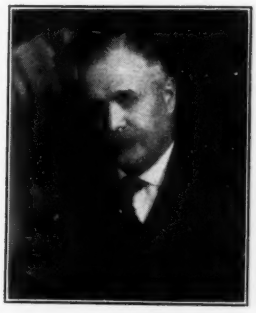
Friday morning a session will be held at 9:45, continuing the topic, Economics of Power Stations, but dealing especially with Fuel, Combustion and related subjects. Addresses will be given by T. A. Peebles, of the Hagan Corp. on Combustion Control in Industrial Plants; by J. F. Shagden, Smoot Engineering Co., on Boiler Room Organization Combustion Control; by Edward Brown, of Allis-Chalmers Mfg. Co., on Effect of Steam Reheating, Stage Feed Water Heating and Boiler Reheating on Steam Turbine Practice and Development; by S. W. Parr and F. C. Straub of the University of Illinois on Embrittlement of Boiler Plate.

It is evident that the sessions will be filled with vital and interesting discussion and that every engineer who is in attendance will carry away much of value which can be applied in his own daily work.

In order that engineers may conveniently divide their time between the Conference and the exhibits, bus transportation on regular, frequent schedule will be provided between the Hotel Stevens and the Coliseum. Exhibits will be found in the booths as shown in the accompanying floor plans and the material to be found in each exhibit is shown in the following directory, which gives detailed booth numbers, exhibit features and representatives who will be at the various booths. Needless to say, all these representatives will be only too glad to discuss power plant problems with all visitors and to give every possible help in solving problems or making suggestions as to equipment.



GEORGE A. ORROK



THOMAS E. MURRAY

Directory of Exhibits

Aerofin Corp. Booths 459-60
Heating units for use singly or in banks with fin tube surfaces and of noncorrodible material. Sections of units to show interior construction and high pressure unit with pump.
Representatives: L. C. Soule, secretary and sales manager; John F. Hale, western representative; M. Noble, factory engineer.

Air Preheater Corp. Booth 74
Ljungstrom air preheater shown by scene-in-action photograph and by models of adaptation to the boiler plant.
Representatives: H. Butt, E. A. Kerbey, G. O. French.

Albaugh-Dover Mfg. Co. Booth 333
Speed reducers of worm and spur gear types with one unit for 800,000 to 1 speed reduction; high grade cut gears.
Representatives: F. G. Eppley, vice president; W. R. Schwab, chief engineer.

Alexander Brothers Booth 166
Tentacular belting transmission for high ratio of speed reduction.
Representatives: J. L. de Rabot, consulting engineer; H. G. Watson, Chicago manager.

Allen-Sherman-Hoff Co. Booth 104
Hydrojet system of ash handling shown by scene-in-action pictures illustrating the removal of ashes from beneath a water wall furnace with hoppers and gates; also the handling of ashes to a sump, to ash storage bins and for filling in of vacant property.
Representatives: F. B. Allen, president; James Stokoe, western sales manager; E. U. Titus, Chicago representative.

Allis-Chalmers Mfg. Co. Booths 91-3
Armor clad switch gear in operation, showing combined unit bus bar construction, circuit breaker, feeder connections and instrument transformers. Roller bearing electric motors, turbine runners for high and low heads and centrifugal pumps. Pittsburgh transformers, Texrope drives, model of 30,000 kw. steam turbine.
Representatives: From Chicago office: F. L. Webster, B. F. Bilsland, W. R. Crawford, Charles McDonald, W. F. Daly, S. Wolff, E. J. Kelley, C. R. Lininger, L. C. Spake, E. C. Luthy, A. A. Dahms, W. Larmoth, L. S. Kleinfeld, J. W. Lyons, Jr., T. J. Schultz; A. K. Birch, Milwaukee.

American Arch Co., Inc. Booth 315
Type A unit supported side wall construction, air cooled bonded refractory wall construction and American suspended arch.
Representatives: G. S. Carrick, general manager of the industrial department; F. D. Hazen, Pittsburgh manager.

American Blower Corp. Booths 8-9
Complete exhibits of dust collectors and air filter for removing dirt from air in ventilating systems and also collecting fly ash from powdered fuel plants.
Representatives: O. B. Cahoon, western district manager power apparatus division.

American Pulverizer Co. Booth 137
Rolling ring coal crusher and details of construction.
Representatives: E. E. Elzemeyer, president; Henry Griesedieck, vice president.

American Society of Mech. Engrs. Booth 22

Andrews-Bradshaw Co. Booth 139
Operating model of the Tracyfier in a boiler drum with glass front showing the action and disassembled parts of complete Tracyfier.
Representatives: R. W. Andrews, J. Lucien Jones, G. M. Kirkpatrick, Pittsburgh.

Armstrong Machine Works Booths 403-4
Standard cast iron trap, steel traps for high pressures, compound trap for large quantities of water, glass model of Armstrong trap in operation to demonstrate the action of the bucket, the valve and the self-cleaning feature.
Representatives: O. E. Ulrich, T. H. Rea.

Atwood & Morrill Co. Booth 137
Turbine and condenser valves, also special valves for low pessure bleeder heating and damper regulators.
Representatives: B. T. Atwood, treasurer; C. T. Atwood, secretary.

Auburn Stoker Corp. Booth 447
Full sized mechanical heavy duty overfeed and new underfeed Auburn stokers in operation.
Representatives: B. O. Fink, president; John Fulton, chief engineer; H. H. Fitch, assistant chief engineer; N. E. Beers, assistant sales manager; George W. Heald, Chicago representative.

Automatic Primer Co. Booth 466
Operating exhibit of centrifugal pump driven by electric motor and with Apco primer operating as automatic sump pump unit.

Representatives: F. H. Bradford, president; J. M. Wilson, vice president; G. K. Mehagan, secretary.

THE BABCOCK & WILCOX CO. Booths 171-2, 211-12

Section of 48-in. diameter Stirling drum; return-bend wrought steel economizer section; forged steel superheater box section; vertical forged steel header for 1400 lb. pressure; manufacture of drum rivets; high pressure water gage glass and fittings; special shapes of high grade firebrick; Enduro and Toncan tubes subjected to corrosive agents.

Representatives: W. E. Sparrow Jr., Chicago manager.

BAILEY METER CO. Booths 213-5

Automatic combustion control equipment for automatic regulation of fuel and air supply in accordance with steam demand, shown in operation. Boiler meters, meter panel boards, fluid meters, pressure and temperature recorders, multi-pointer gages.

Representatives: E. G. Bailey, president; R. E. Woolley, vice president in charge of engineering and sales; H. M. Hammond, sales manager; J. B. Hoelz, Chicago manager; E. W. Fitch, St. Louis manager; R. V. Knapp, D. F. Bekkedahl, W. J. Reeder, W. C. Turner, J. R. Luhrs, mechanical engineers.

BARBER-GREENE CO. Booth 325

BARCO MANUFACTURING CO. Booths 116-7

Flexible joints and lubricated plug valves in section and electrically operated.

Representative: J. T. Ross.

BARRETT-CHRISTIE CO. Booths 401-4

Steam traps, Instant water heaters, shovels and scoops, bearing metals, packings and gage glasses.

Representatives: Henry Barrett, president; J. D. Christie, secretary and treasurer; C. M. White, W. J. Sprenkle, S. O. Olsen, H. B. Westphal.

BARTLETT HAYWARD CO. Booth 452

Fast's flexible couplings demonstrated by sectional models, photographs and showing applications to industrial operation.

Representatives: E. J. Johnson, Chicago district manager; Hugh Benet, John Connor.

BEARIUM BEARINGS, INC. Booth 319

Exhibit of special processed rod from ¼ to 1 in. in diameter adapted for rapid machining; cored and solid bars and special castings for airplane and bearing liner work in machinery, Diesel engines, machine tools and the like; demonstration of non-seizing and non-scoring qualities of metal.

Representatives: H. M. Rees, vice president; George H. Kendall, chief engineer; Milton F. Butler, western representative; Arthur A. Matthews, special representative.

BENTZ ENGINEERING CORP. Booth 469

Model of "Chillblast" air conditioning, washing, cooling and dehumidifying machine to show principles of operation.

Representatives: W. E. Lowell, western manager; R. P. Rasmussen, assistant western mgr.; Alan Perkins, western representative.

BERNITZ FURNACE APPLIANCE CO. Booth 145

Water wall for boiler furnaces with Thayer design of Bernitz carborundum blocks and actual fastening devices; carborundum ventilated floor for pulverized fuel and oil burning furnaces; carborundum perforated and blank face block.

Representatives: Arthur E. Smith, general manager; Lloyd R. Leatherman, Chicago district manager; James N. Macgowan, Detroit district manager.

BETHLEHEM STEEL CO. Booth 189

Oil Burning Equipment; illustrations of Bethlehem pulverizer, Diesel engines and power plant equipment.

Representatives: I. D. Groak, Chicago representative; Mr. Brosseau.

BIGELOW-LIPTAK CORP. Booth 174

Furnace wall and arch products and wall construction.

Representatives: C. A. Smith, chief engineer, Mr. Dreiske, Mr. Chichester.

BLAW-KNOX CO. Booth 409

Electroforged steel grating and flooring; models of radio and transmission towers; preheaters, buckets and steel buildings.

Representatives: D. C. Grove, H. B. Loxterman, J. C. White, Harold Miller.

BOTFIELD REFRACTORIES CO. Booth 436

Adamant and Adachrome cement for laying of firebrick and patching boiler settings, Adamant gun for application of refractories, single ring arch.

Representatives: A. H. Engstrom, sales manager; W. B. Smith, H. F. Kried, manager refractories division of Wm. E. Dee Co., Chicago.

S. F. BOWSER & CO., INC. Booth 164

Xacto meter in operation for measuring liquids as used in industrial plants and for oil burning furnaces. Force feed lubricators, oil filters, lubricating pumps and self-measuring pumps.

Representatives: C. J. Worden, advertising manager; J. A. Merrill, Chicago manager L and F sales; H. E. Bergman, Milwaukee manager L and F sales; H. W. Brown, Chicago industrial sales; H. B. Pflasterer, railroad sales.

BRISTOL CO. Booth 309

Recording and indicating instruments for pressures, temperatures and liquid level; recording electrical instruments for voltage and current; pyrometers for Diesel engine application.

Representatives: L. G. Bean, Chicago district manager; H. A. Graff, F. W. Case, H. W. Moss.

WM. BROS BOILER & MFG. CO. Booth 421

Fire box heating boilers in welded type, also three and four-drum water tube boilers of bent tube design.

Representatives: B. M. Bros, treasurer; A. U. Wetherbee, designing engineer; A. J. Popham, Chicago sales agent.

BROWN INSTRUMENT CO. Booths 16-17

Illustration of principle and action of Brown flow meter on inductance bridge principle, also indicating and recording models of Brown manometer, flow meters with planimeter and integrator attachments and flow meter accessories, including manometers, orifice plates and condensers. Power plant efficiency instruments, including integrating and recording pyrometers, CO_2 meters, gages, thermometers and automatic control equipment. Portable potentiometer, pyrometer and moisture-proof switch.

Representatives: G. W. Keller, sales manager; C. L. Saunders, Chicago manager; R. W. Mayer, Detroit manager; R. W. Conwell, C. E. McGregor, Chicago; W. D. Rolfe, St. Louis manager.

BUFFALO FORGE CO. Booths 123-5

Cinder eliminating fan in operation; various fans for heating and ventilation work and Buffalo Universal iron worker.

Representative: F. B. Stubinger.

BUILDERS IRON FOUNDRY Booth 198

Venturi meters for measuring boiler feed, also Shunt steam meter for small steam mains, shown in section.

Representatives: C. G. Richardson, sales manager Venturi division; W. D. Hess, Chicago manager; J. H. Jewell, Chicago sales engineer; John R. Ratcliff, sales engineer.

BUNDY STEAM TRAP CO. Booths 454-5

Bundy steam traps for special uses, with details illustrated, showing ground joints, knife edge bearings and monel metal valve seats and discs.

Representatives: Everett M. Stevens, vice president and general manager; Fred S. Hickey, Charles W. Naylor, Chicago.

BURNHAM & LINDSEY Booths 195-6

Moore steam turbines, Vulcan soot blowers and Centrifix separators.

Representatives: C. L. Burnham, R. W. Farwell.

BYLLESBY ENGINEERING & MANAGEMENT CORP. Booths 118-19

Models of power plants, including the hydroelectric plant at Louisville, Green Bay steam electric generating plant, Prospect No. 2 of The California Oregon Power Co., Chippewa Falls hydro project.

Representatives: H. Boyd Brydon, mechanical engineer; J. W. Link, hydraulic engineer; H. W. Fuller, vice president in charge of engineering and construction; W. J. Welch, design engineer; H. W. Eales, chief electrical engineer; F. H. Lane, manager engineering and construction.

THE CARBORUNDUM CO. Booths 321-2

Uses of carborundum refractories for water cooled and air cooled settings; Bernitz Thayer water cooled wall; chain grate stoker using carborundum brick along clinker zone.

Representatives: S. A. Fenno, assistant sales manager; R. A. Beverley, Chicago district sales manager; F. M. Oglee, Chicago sales engineer; R. S. Baker, sales representative.

CARRICK ENGINEERING CO. Booth 312

Mercury-actuated master control in hydraulic and electrical types, furnace regulator and adjustable chronometer valve.

Representatives: John G. Hollmeyer, president and treasurer; B. A. Weimer, sales engineer.

CARRIER ENGINEERING CORP. Booths 460-1

Unit air conditioners, Circulair heaters, Carrier ejector processing cabinet, scene-in-action views of ejector dryer and theater section.

Representatives: E. T. Murphy, vice-president and general sales manager; E. R. Heckel, vice-president; D. C. Lindsay, physicist; I. H. Bailey, Wm. H. Moler, H. B. Forbes, engineers.

CARTER BLOXONEND FLOORING CO. Booth 199

End-grain flooring material in sample panels and photographs of installations.

Representatives: A. E. Giese, Chicago manager; L. L. Bucklew, Detroit

manager; John Thomasma, construction superintendent.

THE CASEY-HEDGES CO. Booth 4
Model of multipass boiler with double circulation system; extra heavy riveted seams, illustrations of modern boiler settings; forged steel sectional header.
Representatives: L. H. McGowan, assistant to the president; W. A. Day, Chicago manager.

A. W. CASH CO. Booth 167
Craig system of combustion control and models of pressure regulating devices and stock valves.
Representatives: C. W. Court, Mgr. Comb. Control Div.; W. R. Reitz, J. F. Reiter, Chicago district representatives.

CELITE PRODUCTS CO. Booth 10
Sil-O-Cel insulating materials, including special brick and a furnace partly insulated and partly uninsulated; breechings with inside insulation

CHICAGO CHEMICAL CO. Booth 165
Testing and treating methods for the use of K. W. S. sodium aluminate in the boiler and in conjunction with other methods.
Representatives: H. A. Kern, general manager; A. E. Warner, sales manager; F. H. Thorne, field manager of sales and service; J. A. Holmes, director of service.

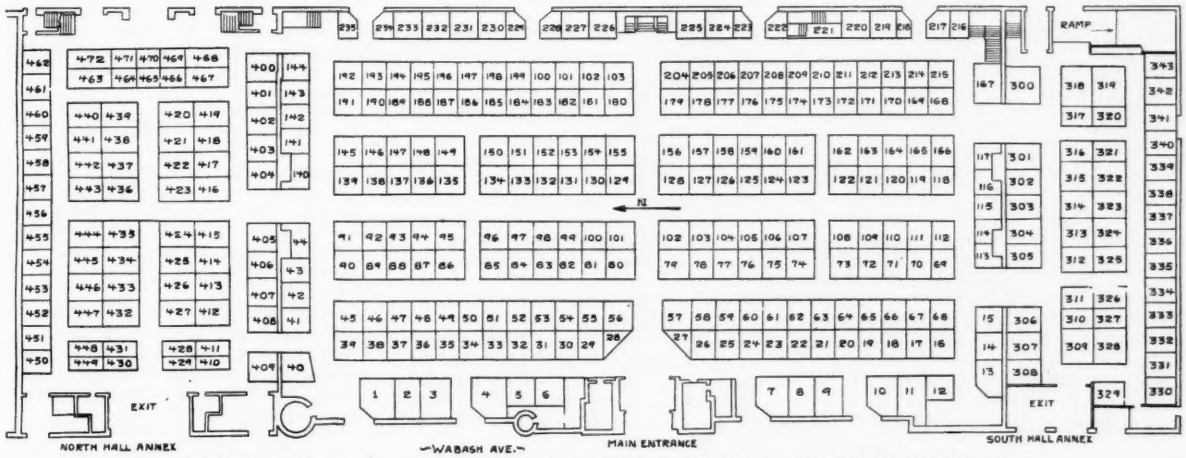
CHICAGO PUMP CO. Booths 1, 2, 3
Duplex set of Flush Kleen sewage ejectors in operation with automatically cleaned screen, new condensation and vacuum pumps, also Condo-Vac of special interest to heating engineers, horizontal centrifugal pumps and standard Underwriters fire pumps.
Representatives: M. I. Weil, president; G. F. Mannion, manager of sales; N. H. Weil, A. C. Durdin, C. J. McCann, R. D. Elliott.

George W. Lyons, Charles McLear, L. D. Cessna.

COMMONWEALTH EDISON CO. Booth 161
This exhibit will present a comprehensive map of Illinois and Indiana showing in detail the super-power network, power lines and steam and hydro power stations of the Insull interests in this important territory.
Representatives: Eric W. Swift, R. L. Matteson.

COMPRESSED SPRUCE PRODUCTS CO., INC. Booths 448-9
Sprucolite pulleys for all kinds of service, also noiseless gears and pinions, rolls, wheels and blocks for absorption of vibration.
Representatives: R. L. Watts, vice-president and sales manager; George Pruner, sales engineer.

CONNERY & CO., INC. Booths 156-7
Expansion stiffener, air-cooled damp-



PLAN OF CHICAGO COLISEUM, SHOWING NUMBERS OF BOOTHS AND THEIR LOCATION

and samples of Fraxite high temperature cement and Celcote boiler wall compound.
Representatives: H. N. Haberstroh, district manager; C. A. Frankenhoff, division sales manager; E. S. Crosby, sales manager; S. Mahon, assistant division manager; N. E. Baxter, R. F. Howerton, T. E. Ventriss, sales engineers.

CENTRIFIX CORP. Booths 232-3
Steam and compressed air purifiers, apparatus for recovery of entrainment in evaporating processes, line separators and suction intake purifiers.
Representatives: L. C. Kerner, vice-president; C. L. Burnham, Chicago manager; George von Haase, O. P. Warner, engineers.

THE CHAPMAN VALVE MFG. CO. Booths 33-4
Chrome nickel steel gate valves for high pressure and temperature work, working model of improved Chapman motor unit for the operation of valves, report of research on piping and flange materials.
Representatives: George E. Fox, chief engineer; James H. Wahl, electrical engineer; Thomas F. Maher, manager of sales; D. T. Malcolm, metallurgist.

CHICAGO BELTING CO. Booths 463-4
Leather belting, leather packings and high pressure leathers; belt dressings in liquid and dry form and belt cements.

CHICAGO RHOPAC PRODUCTS CO. Booth 200
Packings, mechanical and molded rubber goods, carbon dioxide testers.
Representatives: Norman E. Johnson, vice-president; L. L. Ryan, sales manager.

CLARAGE FAN CO. Booths 226-7
Humidifier and unit heater of new design adapted for small installations.
Representatives: Charles Clarage, president; L. O. Monroe, general manager; R. W. Wilson, sales manager; C. R. McConner, A. H. Colbert, H. H. Valiquet, F. D. Lawrence, W. S. Schlichting, Chicago.

CLEVELAND WORM & GEAR CO. Booths 430-1
Standard worm gear speed reduction units and uses of standard worm gearing for special machinery.
Representatives: Howard Dingle, president; F. E. Bardrof, advertising manager; John D. Kinsey, Chicago.

CLIPPER BELT LACER CO. Booth 437
Models of Clipper belt lacers and fasteners; new Clipper speed lacer;
Representative: George Farmer.

COKAL STOKER CORP. Booths 190-1
Automatic Pulverzone stoker electrically operated as in a standard plant installation.
Representatives: George A. Kohout, president; D. A. Campbell, assistant manager; Henry Vick, R. E. Moore,

er, expansion stack connection and covering attachments, air and preheater ducts.
Representatives: William M. Connery, president; E. C. Aucott, secretary; A. D. Stewart, W. J. Henderson, A. H. Charles Dalley.

CONSOLIDATED ASHCROFT HANCOCK CO., INC. Booths 67-8
Cast iron and cast steel safety valves, economizer relief valves, power control valves, cast brass pressure and vacuum gages, for pressures up to 1500 lb.; cast brass and steel and forged steel valves in globe, angle, gate, check and blow-off form for pressures up to 1350 lb., drumhead stop and check valves for pressures up to 600 lb.
Representatives: C. H. Graesser, vice-president; W. P. Bradbury, sales manager; W. E. Jerauld, Boston works manager; Charles Stepan, western manager industrial sales; A. G. Marshall, M. S. Palmer, W. Loos.

COOK ELECTRIC CO. Booth 146
Metal bellows of various metals, automatic fuel oil pumps and regulating devices, gages for high and low pressure and anti-syphon valves; air and damper regulators; automatic steam valves, traps, flexible couplings and heat coil protectors.
Representatives: George R. Folds, president; L. M. Persons, D. C. McKee, E. D. Swanberg, J. F. Jaap.

COOKE SEAL RING Booth 220
Demonstration of the uses of Cooke Seal Ring on high pressure reciprocating pumps in actual operation, on multistage centrifugal pumps with cover removed and for refrigerating machinery in ammonia practice.
Representatives: Rob't E. Cooke, manager; Geo. J. Cooke; Gerald Posta.

COPPUS ENGINEERING CORP. Booth 63
Type C and Vano blowers for forced boiler draft; Coppus Heat Killer for ventilating hot spots in plants, turbo boiler feed pump.
Representative: Harry Himelblau.

CRANDALL PACK NG CO. Booth 193
Mechanical packings in fibrous and metallic types and raw materials for packings.
Representatives: O. W. Wagner, director of sales; James Sampson, Chicago district manager.

CRANE CO. Booths 121-2, 162-3
Large steel gate valve in section; bronze, cast iron, ferrosteel, cast steel and forged steel valves, fittings and flanges.
Representatives: M. W. Link, manager specialty sales department; G. E. Barker, W. F. Lahl, specialty sales department; G. F. Wright, manager and P. J. Taylor, assistant manager engineering sales department.

CRANE PACKING CO. Booth 51
Models showing expansion of inlet ends of condenser tubes into lead-slugged fibres and packing outlet ends flush with metallic packing. Also metallic packing for power plant service and especially for centrifugal pumps.
Representatives: F. E. Payne, A. W. Payne, J. N. Walton, George Ayrscott.

CROSBY STEAM GAGE & VALVE CO. Booth 225
Gages and safety valves; release valves, blowoff valves, indicators and whistles; gage testing apparatus and special relief valve.
Representatives: G. F. Felker, vice-president; E. C. Kenyon, assistant general sales manager; E. W. Zimmerman, Chicago.

THE CUTLER-HAMMER MFG. CO. Booths 110-12
Across-the-line automatic starter in operation. Full line of across-the-line starters; Cutler-Hammer (Dean) valve control equipment and wiring devices.
Representatives: F. U. Webster, advertising manager; C. J. Maloney, manager western district; J. E. Middlekauf, western district.

THE CUTTER ELECTRICAL & MFG. CO. Booths 310-11
2000 amp. 3 pole I-T-E carbon circuit breaker for alternating current up to 550 v. arranged for remote operation; U-Re-Lites in capacities of 1000 amp. and under for alternating and direct current service; 2000 amp. double pole field switch with automatic field discharge clips. Semi-automatic transfer circuit breaker of 1000 amp. capacity.
Representatives: O. M. Bercaw, T. R. Routh, I. S. Allen, E. Swift Newton.

THE DAMPNEY CO. OF AMERICA Booth 76
Apexior protective coatings for metal surfaces and method of application to the internal surfaces of steam equipment.
Representatives: E. F. Gilbert, C. F. Moore, Boston; D. H. Skeen, D. S. Walker, Chicago; A. MacLachlan, Cleveland; F. Dorner, Milwaukee; A. T. Hunter, St. Louis.

G. M. DAVIS REGULATOR CO. Booth 86
Automatic valves for pressure regulation and non return valves for turbine bleeder lines.
Representatives: George C. Davis, president; J. C. Kinsley, George Hochmeister, Harvey Willard.

DEARBORN CHEMICAL CO. Booth 420
Dearborn water treatment, cleaners, rust preventive and lubricating oils, also moving pictures of laboratory processes.
Representatives: James W. Harkins, city sales manager; E. M. Converse, director, department of specialties, Fred B. Horstmann, chemical engineer, M. M. Kutzer, H. M. Harrison, A. C. Herrmann, A. H. Noreen, Chicago; Clyde Loudenback, Detroit.

DETROIT BELT LACER CO. Booth 471
Complete line of belt lacing, closing machines and belt cutters, and Full Speed pulley covering will be shown.
Representatives: George A. Ruessler, Chicago representative; Herman L. Wahl, Richard Doyle.

DEWALT PRODUCTS CO. Booth 342
Wonder Worker machine for woodworking in actual operation, also jointer attachment for use with the Wonder Worker or for direct motor drive.
Representatives: Paul Gardner, sales manager; Harry V. Hogans, J. L. Wickersham, Chicago.

DIAMOND POWER SPECIALTY CORP. Booths 178-9
Complete story of soot and ash deposits in boilers, cause, effect and removal; samples of soot blower elements, hand and electrically operated automatic soot blowers.
Representatives: W. P. Thomas, secretary; G. L. Davis, assistant sales manager; M. J. Miller, C. L. Conrad, L. E. Trotter, E. K. Uebe, B. J. Proetz, E. A. Grimmer.

DIRECT CONTROL VALVE CO. Booth 228

DODGE MFG. CORP. Booths 418-9
Power transmission equipment including split pulleys with wood bushings, hanger shafting and rope drive equipment.
Representatives: A. P. Strong, H. T. Robbins, T. H. Upson, W. W. Dodge.

DRAKE NON-CLINKERING FURNACE BLOCK CO. Booth 148
Armor clad water wall, air cooled walls, non-clinkering blocks.
Representatives: Warren C. Drake, E. B. Priebe, S. M. Finn, Mr. Buckett.

DRI-STEAM VALVE SALES CORP. Booth 323
Full size cut models of throttle, stop and check and other Dri-Steam valves to show construction and operation.
Representatives: A. B. Cross, sales engineer, Chicago; A. A. Kiewitz, sales engineer, N. Y.; W. L. Combs, Detroit; Miss B. Busch.

C. A. DUNHAM CO. Booths 173, 210
Working units of series pumps, differential vacuum pumps, condensation pump and receiver; traps in float and thermostatic form, return traps, air eliminators, packless radiator valves and low pressure reducing valves all in section.
Representatives: C. A. Dunham, president; Oliver J. Prentice, manager; Bruce H. Jarvis, Leslie W. Millar.

DURAMETALLIC CORP. Booths 410-11
Flexible self-lubricating metallic packing in spiral and bar form, also die moulded packing rings and ring sets will be shown.
Representatives: C. C. Hall, vice-president; L. A. Sliter, treasurer; J. M. Bandish, midwestern sales manager.

DUST RECOVERY, INC. Booth 75
Apparatus for removing dust from air, conveying it and collecting it.

ECONOMY PUMPING MACHINERY CO. Booth 11
Centrifugal pumps of improved design including double-suction horizontal, split-case types, heavy duty multistage types, automatic condensation pumps and receivers, centrifugal vacuum pumps and Caisson pumps.
Representatives: R. H. Thomas, president; H. R. Ryan, sales manager.

EDWARD VALVE & MFG. CO. Booth 79
Special 12-in. 900-lb. valve for Super Power Co. of Illinois; double combination radial and end thrust ball bearing type yoke and offset flanged forged steel valves.
Representatives: J. E. McDonald, sales manager; J. F. Hallowell, D. H. Skeen.

EHRET MAGNESIA MFG. CO. Booth 88
Illustration of the lightness and strength of 85 per cent magnesia pipe covering and block insulation, also processes of manufacture.
Representatives: Lawrence L. Shailer, H. G. Hill.

LEWIS M. ELLISON Booths 5-6
Pointer draft gages with straight line movement, dial type draft gage, inclined and vertical tube types, stationary and portable form, U path steam calorimeter.
Representatives: Lewis M. Ellison, Alanson F. Smith, Martin Coco.

EVERLASTING VALVE CO. Booth 45
Twin blow-off unit valve in 600-lb. type; Duplex blow-off unit special for pressures up to 500 lb.; Companion angle valve; regular Everlasting and Flatplug valves and tandem valve model X; special water column valve.
Representatives: John H. Allen, president of the Everlasting Valve Co.; R. W. Siewert, John Patterson, Scully Steel & Iron Co., Chicago.

EX-CELL-O TOOL & MFG. CO. Booth 316
Diesel engine fuel injection system with parts and display of standard drilled jig bushings and grinders and spindles.

FAFNIR BEARING CO. Booths 334-5
Single row radial and double row thrust bearings; transmission equipment with ball bearings; wide inner ring ball bearings; operating exhibits of ball bearing transmission units for shafting and a machine to show the small amount of power required to drive ball bearings.
Representatives: R. N. Hemenway, vice-president and manager industrial bearings division; H. R. Reynolds, chief engineer; S. M. Cooper, advertising manager; R. M. Ring, Chicago manager; T. C. Waddell, C. W. Kramlich, sales engineers.

FAIRBANKS, MORSE & CO. Booths 129-30, 154-5
Diesel engine generating set, sectionalized squirrel cage motor, alternating current and direct current motor-generator sets, ventilating motors and

parts of single and multi-phase alternating current motors. Centrifugal pumps for high speed and high head, also for moderate speed and moderate head in ball bearing types; new side-suction centrifugal pump.

Representatives: C. W. House, manager machinery department; G. A. Adkins, manager oil engine department; Earl Chambers, manager electrical department; R. V. Cook, manager pump department; N. R. Granger, J. S. King, E. L. Morton, R. M. Kinney, C. B. Stibolt, sales representatives; J. D. Harper, manager Diesel engine division; M. B. McNeille, manager pump division; L. J. Osborn, manager electrical division; R. L. Howes, Diesel engine division; M. O. Southworth, electrical division; Lloyd Yost, manager, Lee Madeley, George Oetzel, Frank Mason, research division.

FILTRATORS CO. Booth 303

Demonstration of the application and use of Filtrators for keeping boilers permanently clean.

Representative: Boris Kitchin, vice-president and general manager.

THE FISHER GOVERNOR CO., INC. Booth 37

Liquid level controllers, float and pressure reducing valves, steam traps, constant and excess pressure pump governors, pressure and gas regulators and gas fuel governors.

Representatives: L. W. Browne, vice-president; O. M. Galiher.

FOSTER ENGINEERING CO. Booth 160

Automatic valves of drop forged cast steel chrome construction for high boiler pressures and temperatures, pressure reducing regulators and pump governors; sight-flow box in operation and Foster flexible ball joints.

Representatives: Charles A. Olson, president and general manager; Almer W. Johnson, Chicago manager; M. S. Maleson; C. R. Emerson, vice-pres. and sales manager.

FOSTER WHEELER CORP. Booths 180-3

Aero coal pulverizer with magnetic separator; full size sections of Foster sectional air heater and water cooled furnace surface, sections of superheater surfaces, including radiant heat type; of economizer surface and tubular oil still construction; full size section of Foster water back; superheater elements, photographs and drawings of condensers, steam jet air pumps, evaporators and feed water heaters; cooling towers and Crescent brand copper and brass tubing.

Representatives: K. H. Bedell, W. E. Burks, P. R. Greenman, T. G. Hart, Louis Lanyi, W. F. Meyer, Thos. H. Wilkins, O. E. Anderson, A. Metzger, A. Pretty, Arno N. Dietze, W. L. Martwick, F. G. Page, J. K. Seabright.

THE FOXBORO CO., INC. Booth 61

New steam flow meter; indicating and recording pressure gages and thermometers with multiple pen recorder for temperature and pressure; draft gages and power plant instruments.

Representative: C. H. Roessner, Chicago district manager.

O. E. FRANK HEATER & ENGINEERING CO. Booth 66

Heat exchanger with split shell to give access to exterior of all tubes and U-tube storage type heater.

Representatives: Mrs. Olive E. Frank, president; Herbert T. Wilder, Buffalo.

FULLER LEHIGH CO. Booths 168-70

Fuller Lehigh storage and direct fired pulverized coal installation, including pulverizing equipment, feeders, Calumet burners, transporting system. Bailey water cooled furnace wall installations, showing various types of refractory faced block and glass inspection door.

Representatives: E. J. Billings, vice-president; W. E. East, Chicago manager; H. D. Lehr, Chicago; F. C. Brandt, St. Louis, L. W. Marso, Cleveland manager; R. A. Hawk.

FURNACE ECONOMY CO. Booth 462

Air cooled furnace wall and descriptive matter.

Representative: M. C. Neil.

FURNACE ENGINEERING CO., INC. Booths 96-7

Simplex unit system of pulverizing and burning fuel; Drake armorclad wall construction; animated pictures of the Simplex unit.

Representatives: A. B. Carle, assistant sales manager; E. B. Priebe.

THE GARLOCK PACKING CO. Booth 453

Mechanical model display of oil return packing and ammonia packing and complete line of packings for all service.

Representative: H. J. Ramshaw, sales manager, Chicago.

GRAVER CORP. Booths 150-1

Water treating equipment, tanks and steel plate equipment.

Representatives: J. J. Felsecker, manager of water softening sales; J. C. Winslow, manager of sales promotion.

A. P. GREEN FIREBRICK CO. Booth 175

Refractories and plastic materials for high temperature work in furnaces; air setting cement and special shapes of fire brick.

Representatives: George E. Ford, vice-president; J. Harrison Brown, secretary; H. B. Plunkett, sales manager.

GRINNELL CO. Booths 441-2

Triple XXX line of products for pressures of 400, 600 or 900 lb. Thermolier unit type heater; Grinnell Equiflo valve for forced hot water heating system; Quartz bulb and standard sprinkler head.

Representatives: A. Q. Moulder, manager, heating, power and industrial piping sub-division; Thomas Floro, plant manager; Howard E. Branch, department of publicity and promotion; F. M. Daugherty, central district manager, heating, power and industrial piping and supply sub-division, Warren, Ohio; C. W. Little, supply sub-division, Detroit, Mich.

GRISCOM-RUSSELL CO. Booths 426-7

Evaporators and heat exchanging apparatus including the Reilly and G. R. Bentube type, also Russell water heater and Multiwhirl oil coolers, Stratton separators and generator air coolers.

HAGAN CORP. Booths 58-9

Steam purifier, control systems, and system of boiler water conditioning.

Representatives: J. M. Hopwood, president; Dr. R. E. Hall; T. A. Peebles, A. G. Burke, Jr., Chicago representative; R. E. Busch, R. R. Donaldson, M. S. Gare.

JOSEPH HARRINGTON CO. Booths 438-9

Stoker equipment for small and medium size boilers, including King Coal stoker for medium size and the junior stoker for setting under fire box and other low set boilers.

Representatives: Joseph Harrington, president; Jeff Corydon, sales manager; C. A. Beckman, R. E. Little, sales engineers.

ARTHUR HARRIS & CO. Booth 222

Floats, expansion joints, Harbronz and copper work.

Representatives: A. J. Harris, G. C. Harris, A. W. Baumann.

THE HAYS CORP. Booth 313

Hays apparatus including water operated CO_2 recorders, pointer type draft gages, gas analyzers, portable test set, inclined vertical and U-tube gages for draft, pressure and pressure differential.

Representatives: P. T. Sprague, president; Shirl M. Rudolph, J. W. Murphy, J. T. Vollbrecht, P. D. Armstrong, Chicago.

HEINE BOILER CO. Booths 28-30

See International Combustion Engineering Corp.

HENSZEY DE-CONCENTRATOR CO. Booth 105

Display of Henszey system of continuous blowdown.

Representatives: F. W. Clasmann, D. S. Walker.

E. VERNON HILL CO. Booth 338

Air testing and gas testing apparatus, including thermometers, draft, gages, CO_2 analyzers and the like.

Representatives: Dr. E. V. Hill, P. J. Marschall, E. B. Stark.

HIMELBLAU, AGAZIM & CO. Booth 65

Ames Iron Works, automatic side and center crank engines, also horizontal and vertical unaflow engines. Boiler Engineering Co.'s Beco baffle with corrugated expansion joints. Boiler Room Improvement Co.'s smoke indicator and McNeill liquid level gage. General Air Filters Corporation's air purification equipment. Korfund Co., Inc., Vibro damper and vibration reducing materials. Schade Valve Mfg. Co. regulating and reducing valves. Sterling Engineering Co. Thermotrol for regulating radiator temperature. Lehnco Co. automatic boiler and equipment control regulators according to demand.

Representatives: Harry Himelblau, T. Agazim, F. J. Murray, F. C. Peterson, J. E. Jensen.

HOLLOW CENTER PACKING CO. Booth 471

Exhibit of five styles of Ovalhole packing to meet all packing requirements.

Representatives: Ernest H. Smith, president; A. P. Sertzel, Chicago branch manager; Mr. Goldback.

ILLINOIS ENGINEERING CO. Booths 405-6

Glass model of trap in actual operation to demonstrate features of construction and action, also electric boiler, boiler feed pump, piping and other details.

Representatives: Robert L. Gifford, president; James C. Matchett, vice-president; Gordon L. Harris, secretary; John L. Ehretsman, H. S. Thompson.

ILLINOIS STOKER CO. Booth 138

Illustrations of the latest installations of chain grate stokers, also details of the stoker showing construction and operation.

Representatives: Phil Polster, chief engineer; Charles W. Warriner, Alton; Ernest E. Lee, John L. Higgins, T. E. Shaughnessey, C. M. Hardin, Chicago.

INGERSOLL-RAND CO. Booths 108-9

Cameron pumps and special features

of Ingersoll-Rand condensers. Multi stage boiler feed pumps for pressures up to 1500 lb. with Kingsbury thrust bearing.

INSTANT WATER HEATER SALES DIVISION Booth 401
Copper tube steam water heater and flow control connected to steam and water lines to heat hot water, shown in operation.
Representatives: D. F. Priser, general manager Instant Water Heater Co.; H. B. Fridstein, sales manager, Instant Water Heater Sales Division.

INSULATING PRODUCTS CO. Booth 472
Illustration of Foster economizers insulated with Webers insulating cement, also panels of air ducts.
Representatives: W. J. Greer, president; F. Elizer, sales manager; Robert Graf, Pittsburgh manager.

INTERNATIONAL COAL CARBONIZATION CO. Booths 54-6
See International Combustion Engineering Corp.

INTERNATIONAL COMBUSTION ENGINEERING CORP. Booths 28-30; 54-6
Record from N. E. L. A. report of power plants using pulverized fuel with storage equipment; boilers manufactured by the company's constituent subsidiaries will be illustrated with typical settings; horizontal firing of pulverized fuel will be illustrated, also Lopulco burner for preheated air, fin walls, air preheaters and liquid level indicators. Elements of stoker and pulverized fuel equipment, scene-in-action displays of steam generating units and layouts of Dry Quenching and Coal Carbonization equipment.
Representative: J. D. Harrison, Chicago manager.

THE INTERNATIONAL NICKEL CO. Booths 141-2
Commercial forms of monel metal, including rods, sheet tubing, forgings and castings; also vital parts of power plant equipment as manufactured from monel metal.
Representatives: L. Muller Thym, R. E. Mason.

IRVING IRON WORKS CO. Booths 432-3
Steel ventilating flooring, Vizabledg Safsteps, reinforcement and surface armor for concrete bridge floors.
Representatives: E. Brodhead, sales manager; C. S. Line, B. O. Buchanan, J. T. Bayless, sales engineers.

JENKINS BROS. Booth 202
Bronze and iron valves in globe, angle, check, cross and Y types for standard, medium and extra heavy pressures. Rapid action self-closing, modulating and other special valves for high pressures; molded and rolled mechanical rubber goods. Moncrieff gage glasses.
Representatives: H. B. McLelland, H. A. Taif, George Davidsen, W. E. Lueders, R. B. Osgood.

JOHNSON SERVICE CO. Booth 300
Temperature control systems for steam and hot water heating and details of apparatus.
Representatives: P. A. Riccis, Frank B. Brophy, Victor M. Lathers.

W. A. JONES FDRY. & MACHINE CO. Booth 90
Spur and worm gear speed reducers in double type spur gear and heavy duty worm gear types.
Representatives: W. S. LaScelle, L. C. Meyer, J. A. Marland.

M. W. KELLOGG CO. Booths 102-3
Piping materials for high pressure service and Dean power operated gate valves.
Representatives: H. B. Kendall, sales manager; P. Payne Dean.

THE KELLY CO. Booth 64
Self grinding globe and angle valves and valve controllers.
Representatives: P. J. Kelly, H. Himelblau, T. Agazim, A. E. Jacobson.

KENNEDY-VAN SAUN MFG. & ENGRG. CORP. Booth 445
Kennedy air-swept ball and tube mills, demonstrated by scene-in-action picture; photograph of the S. S. Mercer, the first steamship to use pulverized coal in crossing the Atlantic.
Representatives: J. B. Hampton, Chicago manager, 5207 Woodlawn Ave.; Fred Olvey, Chicago sales engineer; T. J. Shearer, New York.

KIELEY & MUELLER, INC. Booth 402
High and low pressure regulating and reducing valves, damper regulators, high pressure water line controllers, return and lift traps.
Representatives: C. H. Dutcher, manager; Mr. White.

WM. F. KLEMP CO. Booth 470
Diamond Grating for power house floors, walkways and all industrial purposes and Diamonose stair treads made from the same material.
Representatives: W. F. Ogle, A. E. Sangdahl, John M. Keown.

KORFUND CORP. Booth 66
Vibro-Damper and vibration insulating materials.
Representative: S. Rosenzweig.

THE LABOUR CO. Booth 440
Operating exhibit of self-priming centrifugal pump, with glass suction line illustrating ability to handle air; portable pumping unit direct connected to gasoline engine; castings of acid resisting material.
Representatives: H. E. LaBour, president; N. A. Pedersen, J. M. Thomas, S. J. Thomas.

LADD WATER TUBE BOILER CO. Booths 28-30
See International Combustion Engineering Corp.

THE LEAVITT MACHINE CO. Booth 147
Valve reseating machines for globe and gate valves and for pump valve seats.
Representatives: E. S. Hersey, sales engineer.

ERNEST E. LEE CO. Booths 135-9; 146-9
Copes feed water regulators; Manistee boiler feed pump; Dexter reseating machines; Drake furnace blocks and wall construction; Tracyfier steam purifier; American ring coal crusher; Atwood & Morrill valves; Illinois chain grate stokers; Apex CO_2 instruments.
Representatives: Ernest E. Lee, John L. Higgins, Charles M. Hardin, Thomas E. Shaughnessy.

LIBERTY ELECTRIC CORP. Booth 306
Liberty valve operators and switch equipment.
Representative: Charles A. Craig, sales manager.

GEO. B. LIMBERT & CO. Booths 131-2
Fabricated pipe including welded manifold, Vanstone laps, welded flanges and outlets and special compound bend; reducing Vanstone laps and welded spuds and cast steel and cast iron flanged fittings for 125 and for 250-lb. pressure.
Representatives: D. C. Showers, vice-president; F. R. Lynch, assistant sales manager; M. R. Paulson, general superintendent; A. C. Peterson, assistant general superintendent; Ed. Medal, in charge of engineering dept.

THE LINDE AIR PRODUCTS CO. Booth 324
Equipment and supplies for oxy-acetylene welding and specimens of the new Shear-Vee joint for cast iron pipe.
Representatives: R. W. Boggs, technical publicity department; C. E. Ziesel, H. H. Griffith, E. J. Hayden, J. W. Haygood, W. C. Harrison, George Schmid.

LOCKE REGULATOR CO. Booths 454-5
Pressure reducing, float control, non-return, balanced, exhaust relief and safety shut off valves; damper and hydraulic regulators; automatic engine stop equipment.
Representatives: Naylor-Hickey Corp., Chicago.

J. E. LONERGAN CO. Booths 454-5
Safety valves, gages, water gage fittings, oil cups and whistles.
Representative: A. St. C. Tomes, vice-president.

LOVEJOY TOOL WORKS Booth 332
L-R Flexible couplings and boiler makers' tools will be shown.
Representatives: W. H. Dangel, M. W. Dangel, Robert Rostron.

THE LUNKENHEIMER CO. Booths 184-5
Steel, monel, iron body and bronze valves for all power plant purposes. Steel valves with monel mountings for high pressures. Electrically operated gate valves and valves in large and small types for extremely high pressures.

JOHN W. MABBS Booth 229
Rawhide packing, packless radiator valves, unit heaters.
Representatives: For the Mabbs Hydraulic Packing Co., John W. Mabbs, president; E. C. Kavanaugh, secretary; for the Marsh Valve Co., Wm. C. Marsh, president; for the Thermidaire Corp., F. Ruoff, president; E. K. Campbell, treasurer.

MANISTEE IRON WORKS CO. Booth 136
Roturbo pumps in multi-stage and single-stage form, also details of Roturbo impellers and volute construction.
Representatives: D. J. Rowland, E. S. Quakenbush, A. C. Olches.

MAPLEWOOD MACH. CORP. Booth 343
Gray sheet metal cutters, Nos. 00 and 1, will be demonstrated, together with the Sievert power flanging machine.
Representatives: William M. Ward, W. Lemke, A. Stevenson, Hans Rasmussen; for Dries & Krump Mfg. Co., Messrs. Dorsey and Schafer.

MARION MACHINE FDRY. & SUPPLY CO. Booths 407-8
AB soot blower and detail parts and demonstration of action, Marion Gulf Stream water heater for instant heating of water by steam.
Representatives: G. C. Kumming, sales manager; A. L. Bolinger, Edward Beal.

MECHANICAL MFG. CO. Booths 465-7

MERCON REGULATOR CO. Booths 106-7

MERRICK SCALE MFG. CO. Booth 308
Conveyor Weightometer for measuring conveyor-handled material in operation weighing coal; Mechanical Weighman for weighing hopper handled material, in operation weighing water.
Representatives: F. P. Hambright,

sales manager; T. F. Corpron, service and sales engineer.

MIDWEST PIPING & SUPPLY CO. Booth 204

Globack joints with spherical backs for lap and spherical joint contact, also micro photographs of hot-worked metal structure.

Representatives: J. McC. Moffett, secretary; Paul F. Witte, advertising manager.

MILES ENGINEERING CO. Booth 216

Automatic electric controls for combustion and all industrial purposes.

Representatives: W. J. Miles, mechanical engineer; F. A. Moreland, sales manager; T. J. Leitz and Glenwood Miles, engineers.

MODINE MFG. CO. Booths 340-1

Thermodyne unit heaters, cabinet heaters and concealed heaters.

Representatives: C. J. Rice, sales manager of the heating division; A. G. Dixon, assistant manager of sales; O. E. Desmond, advertising manager.

MOORE STEAM TURBINE CORP. Booth 196

Combined turbine and reduction gear, turbine driven boiler feed pump with pump governor, 1500 hp. 3-bearing reduction gear pinion.

Representatives: M. D. Church, president; G. R. Probst, sales manager; C. L. Burnham, Chicago.

MOREHEAD MANUFACTURING CO. Booth 413

Direct return trap as used in the Morehead back to the boiler and condensation drainage systems, also receiver and various detail parts.

Representatives: A. Fitzgerald, president and general manager; V. A. Houghton, Chicago district engineer.

MULTICELL RADIATOR CORP. Booth 434

J. W. MURPHY CO. Booths 313-4

Esterline meters and Hay CO_2 and draft recording apparatus, Cochrane flow meter.

Representatives: Phillip Sprague, J. W. Murphy, P. D. Armstrong, J. T. Vollbrecht, W. H. Pugsley.

MURRAY IRON WORKS CO. Booth 330

Complete turbine open for inspection, Model of Murray duplex boiler, charts and layouts of equipment.

Representatives: W. A. Gordon, Jr., E. E. Maher.

NASH ENGINEERING CO. Booths 80-2

Vacuum and condensation pumps; Jennings-Hytor heating systems, circulating pumps for hot water, condensing systems and sewage ejection.

Representatives: J. M. Stannard, G. W. Clucas, R. L. Sutherland, H. C. Crane.

NATIONAL CO., INC. Booth 76

Water column illuminators for distant reading.

Representatives: Mr. Ready, president; Mr. Wilson, engineer.

NATIONAL AIR FILTER CO. Booth 443

Air filtration equipment for heating and ventilating plants.

Representatives: J. L. Harpham, sales manager; H. E. Birkholz, R. G. Birkholz, research engineers; W. G. Frank, chief engineer; Q. G. Ewen, T. Kellberg, sales engineers; F. S. Auty, advertising manager.

NATIONAL POWER CONSTRUCTION CO. Booth 444

Photographs of settings as made by the company and descriptions of jobs recently completed.

Representatives: Glenn E. Reynolds, Arthur Scheying, William Matthews.

NATIONAL TUBE CO. Booths 301-2

Shelby seamless tubing, National boiler tubes and pipe and Van Stone flanges.

Representative: W. L. Shaffer.

NAYLOR-HICKEY CORP. Booths 454-5

Lonergan steam specialties, Bundy traps and Locke pressure regulators.

Representatives: C. E. Naylor, president; Fred S. Hickey, vice-president; A. J. Bertaux, purchasing agent; W. F. Ebert, C. J. Kerry, L. E. Warren.

THE HERMAN NELSON CORP. Booths 20-21

HiJet unit heaters in three models; Univent for office buildings; invisible radiator for building into wall; Wedge Core radiator section.

Representative: R. H. Nelson.

NORMA-HOFFMANN BEARINGS CORP. Booths 35-6

Ball, roller and thrust bearings and fitting of these bearings to reduction gear units.

Representatives: T. J. Harley, Chicago manager; D. E. Batesole, assistant engineering manager; C. H. Wallace, T. M. Kaino, Chicago representatives.

NORTHERN EQUIPMENT CO. Booths 135 and 149

Feed water regulator and pressure control valve; orifice valve for condensate drainage control; outboard ball bearing valve; tripper type thermostat; Copes feed water regulator in moving exhibit; Copes pump governor, valve movement indicator and control valve.

Representatives: E. W. Nick, president; V. V. Veenschoten, vice-president; C. E. Wolff, sales manager; Ernest E. Lee, Chicago.

WM. W. NUGENT & CO. Booth 192

Oil filters, oil cooling devices, oil pumps, telescopic oilers and sight feed valves.

Representative: Corliss D. Nugent.

NUWAY BOILER & ENGINEERING CO. Booth 115

Water wall boiler and super-circulation boiler of the company's manufacture.

Representatives: P. G. Kaiser, president; E. A. Kaiser, secretary and treasurer.

THE S. OBERMAYER CO. Booth 456-8

Cement gun for one man operation; Ramtite plastic fire brick; high temperature cement.

Representatives: J. L. Cummings, refractory manager; George F. Doyle, field man; F. Corley, V. C. Bruce.

PAIGE & JONES CHEMICAL CO. Booth 339

Model of rapid upward flow Zeolite water softener installation built to scale; FFF boiler feedwater treatment as used by railroads and boiler plant operators.

Representatives: C. L. Sidle, general sales manager; O. E. Mitchell, Indiana; Wm. D. Williams, Chicago.

PEABODY COAL CO. Booths 152-3

Modern Coal Burner, a small automatic stoker for average heating plant.

Representative: Vernon G. Leach, combustion engineer.

PEABODY ENGINEERING CORP. Booth 423

Combined oil and pulverized coal burner having insulated front plate for use with preheated air. Gas burner which can be used as combination for gas and oil, coal and gas or coal, oil and gas.

Representatives: J. P. Leask, vice president; J. J. Somes, Chicago; D. P. Graham, New York.

THE PERMUTIT CO. Booth 224

Scale model of water softening and filtering equipment for industrial plant showing complete details. Ranarex instruments for CO_2 recording.

Representatives: F. S. Dunham, N. P. Sherwood, I. J. Bready, H. J. Keays, G. A. Weinhold, J. H. Murphy.

PIPE BENDING PROCESS CO. Booth 331

Features of processing of short radius bends, of any thickness material, to minimum radius equal to pipe diameter, designed to maintain strength equal to or greater than original straight pipe.

Representatives: E. H. Courtenay, vice-president; L. M. Zimmer.

PITTSBURGH PIPING & EQUIPMENT CO. Booths 126, 158

Welded headers and nozzles, welded flange joints, pipe bends and construction for pressures up to 900 lb. and temperatures up to 750 deg.

Representatives: Robert Whyte, general manager of sales; Berford Brittain, Thomas N. Bishop.

PLIBRICO JOINTLESS FIRE BRICK CO. Booths 133-4

Section of boiler furnace wall with Plibrico lining; moving picture showing the use of Plibrico and model section to illustrate adaptation of Plibrico to water walls.

Representatives: I. S. Pieters, vice president; W. A. Schaefer, secretary; J. E. Anderson, C. W. Peacock, I. Kuttnauer, A. Macdonald.

WM. A. POPE CO. Booth 85

Pipe system construction, heating specialties and piping installations.

Representatives: Wm. A. Miller, R. A. Widdicombe, S. Austin Pope.

THE PORTER-CABLE MACHINE CO. Booth 234

Portable electric hand tools, including sander for surfacing, portable saw, combination belt sander and grinder and universal milling attachment.

Representative: W. Roy Vernon.

THE WM. POWELL CO. Booths 230-1

Complete processing from foundry to finished product of bronze, iron and steel valves; hand and electrically operated steel valves for pressures from 150 to 900 lb.; full line of bronze, iron and steel valves in globe, angle, gate, check and safety form; oilers, lubricators, grease cups, water gages and whistles.

Representatives: William Heilig, Cincinnati; E. F. Smith, Chicago.

THE POWER PLANT EQUIPMENT CO. Booth 412

Marley superheaters for return tubular boilers, Marley spray cooling equipment and Marley steam purifier.

Representatives: L. T. Mart, Kansas City; W. E. Rolston, Chicago manager.

POWER PLANT SPECIALTY CO. Booth 40

Chemical feeder for water softening purposes and conventional arrangement of water softeners.

Representatives: W. H. Stevenson, president; M. B. Peirson, secretary; N. W. Hobson, engineer.

THE POWERS REGULATOR CO. Booth 451

Thermostatic temperature control and regulators, cold water mixers,

steam traps and indicating thermometers.

Representatives: F. W. Powers, treasurer and general manager; A. E. Schad, general sales manager; W. P. McFarland, E. W. Rietz, L. O. Weldy, R. A. Kimble, Mr. Mueller.

HENRY PRATT CO. Booths 46-7

Phillips expansion joint and operating coal spout swinger.

Representatives: W. S. Smith, president; S. B. Smith, W. H. Phillips, E. J. Klika.

PUBLIC SERVICE CO. OF NORTHERN ILLINOIS Booth 203

Special exhibit of the industrial opportunities in the Chicago district and also in the Great Lakes basin and Mississippi Valley, with photographs and descriptive matter on the facilities of the plants of the company.

Representatives: George R. Mitten, George C. Heisterman, Frederick C. Mackey.

QUIGLEY FURNACE SPECIALTIES CO. Booths 13-14

Mixture and use of Hytempite cement illustrated by motion pictures; also the Quigley refractory gun for applying plastic material, Triple-A solutions for making metal and masonry surfaces acid, alkali and water proof, and an acid-proof cement for masonry exposed to acid films.

Representatives: W. H. Gaylord, D. F. McMahon, New York; H. M. Thompson, F. J. Bonner, Chicago.

RAILWAY & INDUSTRIAL ENG. CO. Booth 304

RAMSEY CHAIN CO. Booth 24

Two operating exhibits of sprocket driving chains to show the free action of roller bearing compensating joints.

Representatives: J. H. Ramsey, vice president; D. I. Wheeler, S. I. Anderson.

THE RAWLPLUG CO., INC. Booth 221

Rawlplug fibre screw anchor, Rawldrill for masonry work and Simbi electric hammer for percussion drills.

Representative: H. G. Janton, exhibition manager.

READING STEEL CASTING CO. Booths 187-8

Production control research and service methods shown in a picture story, also specimens of large size steel and iron valves with motor operation.

Representatives: R. T. Hatch, general manager of sales; J. P. Ferguson, sales engineer; A. W. Taggart, Chicago district sales manager; C. H. Molitor, R. F. Hodge, G. J. Helfrich, H. P. Howland, H. W. Barclay.

REED AIR FILTER CO. Booth 450

Reed streamline automatic air filter in operation; unit air filter compressor filters, high pressure filters for oil and moisture removal; Circulair convection heater for replacing cast-iron radiators.

Representatives: H. C. Murphy, vice president and director of sales; J. R. McConnell, sales manager; C. P. Hegan, vice president and chief engineer; J. F. Reed, president, Circulair Heat, Inc.

REEVES PULLEY CO. Booth 140

Variable speed transmissions of new design.

Representatives: C. M. Reeves, vice president; A. E. Shibley, Chicago manager; C. L. Irwin, F. T. Moore, H. M. Glessner.

REFINITE CO. Booth 219

THE RELIANCE ELECTRIC & ENGINEERING CO. Booths 326-7

Protective devices for electric motors, water and dust tight motors, alternating and direct-current motors in disassembled exhibits.

Representatives: J. W. Corey, assistant sales manager; R. O. Herbig, Chicago manager; E. E. Helm, Birmingham manager; W. A. Kelley.

REPUBLIC FLOW METERS CO. Booths 70-73

Steam flow meters, water meters, CO_2 meters, draft instruments, pyrometers, liquid level indicators. Boiler meter panel with multiple recorder and animated boiler view, showing records required for efficient operation.

Representatives: J. D. Cunningham, president; G. D. Conlee, chief engineer; A. F. Spitzglass, research engineer; S. C. Vail, H. H. Skabo, C. W. Parsons, Chicago; J. G. Tigerman, Kansas City; G. G. Armstrong, St. Louis; J. S. Whelan, Detroit; K. B. Roudebush, Cincinnati; M. D. Johnson, Milwaukee.

RICHARDSON SCALE CO. Booth 328

Working full size model of Richardson scale for weighing coal from overhead bunker to hoppers of individual boilers or pulverizing equipment.

Representatives: N. C. Webster, J. Instone, H. E. Matson, W. A. Carte.

RISHER FIRE BRICK CO. Booth 89

High temperature cement, fire brick, fire clay and fire brick shapes.

Representatives: H. E. Risher, president; H. O. Engstrom, secretary; E. H. Pratt.

ROLLAND-GARDNER & CO., Booth 78
See D. H. Skeen & Co.

ROME BRASS RADIATOR CORP. Booth 337

Robras lightweight, all brass, welded sectional radiator, Robras Electric Steam Radiator, and Robras De Luxe Unit.

ROWAN CONTROLLER CO. Booth 314

Complete line of automatic motor starters illustrated in operation.

Representative: J. S. Rowan.

ROXANA PETROLEUM CORP. Booth 307

SARCO CO., INC. Booths 26-7

Steam traps for the industrial field, temperature regulators for hot water service, regulators for refrigeration work, low pressure vacuum and vapor heating devices, including inlet valves, thermostatic traps and other equipment.

Representatives: G. H. B. Burke, E. J. Ritchie, O. G. Jenner, J. H. Ford.

SAUERMAN BROS. Booths 18-19

Working model of power scraper installation for storing and reclaiming coal, also motion pictures of typical installations made by the company.

Representative: George R. Moore.

SCHUTTE & KOERTING CO. Booth 60

Herringbone gear pump in operation with water jet eductor; spur and herringbone gear pumps; stop, check and piston valves, steam jet thermo compressor; complete line of jet appliances for handling liquids.

Representatives: A. C. Nell, Chicago manager; E. J. O'Brien, St. Louis manager.

SHEPARD ELECTRIC CRANE & HOIST CO. Booth 329

LiftAbout and close clearance hoist in operation; photographs of applications of hoisting equipment.

Representatives: Robert T. Turner, sales manager; Walter B. Briggs, Chicago district manager; Gerald G. Robbins, Harry A. Baugh, Chicago.

D. H. SKEEN & CO. Booths 74-79, 102-7

Ljungstrom air preheater in models and by scene-in-action photograph. Hydrojet system of ash handling and conveying. Apexior protective coatings for metal surfaces. High efficiency dust collectors. Edward forged steel valves for high pressures and temperatures. Non-segregating coal distributor. Henszey continuous blowdown with thermal recovery and regulation in proportion to the amount of impurities. Piping materials for high pressure steam service and Dean Power operated gate valves. Standard pressure regulators and constant excess pressure regulator for use with boiler water level controllers. Water column illuminator with special method of lighting. Governors, regulators and valves. Ventilated steel flooring and safety steps for stairways.

Representatives: For Air Preheater Corp., H. Butt, G. O. French; for Allen-Sherman-Hoff Co., F. B. Allen, E. U. Titus, J. Stokoe; for Dampney Co. of America, E. F. Gilbert, C. F. Moore, D. S. Walker, R. B. Hankins; for Dust Recovery, Inc., H. H. Bubar, C. E. Doll; for The Edward Valve & Mfg. Co., J. E. McDonald, E. A. Kerbey; for Rolland Gardner Co., R. Gardner; for Henszey De-Concentrator Co., F. W. Clasmann; for M. W. Kellogg Co., H. B. Kendall, P. Payne Dean; for Mercon Regulator Co., E. T. McCarthy; for National Co., R. B. Hankins; for D. H. Skeen and Co., D. H. Skeen, W. M. Huck, W. E. Rolston, M. G. Hughes, P. L. Richtmyer; for Tri-Lok Co., W. McKee, E. U. Titus.

S K F INDUSTRIES, INC. Booths 38-39

Scenic background illustrating the wide use of the company's products and with novel illuminating features; transmission equipment and mechanical demonstration of the advantages of ball and roller bearings.

Representatives: R. H. DeMott, D. W. McAllen, W. R. McIlroy, R. C. Byler, J. B. Castino, A. Alven, W. B. Pusey, P. A. Carlson, H. A. Gumm, R. Unger.

SKIDMORE CORP. Booth 120

Return line vacuum and boiler feed pump on interceptor base also cut out section of the unit to show the assembly.

Representatives: B. Skidmore, Jr., president; F. H. Sprague, secretary; W. H. Eagan, G. D. Crider, H. G. Liptrott.

M. B. SKINNER CO. Booth 15

Pipe repairs and saddles, valve reseating tools and Bibb cock reseaters.

Representatives: K. G. Merrill, vice president; F. A. McMurray, sales manager; W. W. Brown.

SMITH-MONROE CO. Booth 403

Gast air separators.

Representative: R. O. Monroe.

SNAP-ON WRENCH CO. Booth 87

Snap-On socket wrenches, Blue Point open end wrenches, Simplex open and ratcheting wrenches and a line of hand tools.

Representatives: C. H. Tennyson, C. W. Edwards, John Schieldknecht.

STANDARD OIL CO. Booth 159

Power plant lubricants including oils for steam and Diesel engines, air compressors, steam turbines and other power plant apparatus.

Representative: E. J. Bohnen.

STANNARD POWER EQUIPMENT CO. Booths 83-4

Photographs and literature covering steam pumps, deep well power heads, centrifugal pumps, insulation for underground piping and underground steam conduit.

Representatives: J. M. Stannard, president and treasurer; George W. Clucas, secretary; W. H. Evans, Ralph Sutherland, J. J. Hayes, H. C. Crane, A. O. May.

STEPHENS-ADAMSON MFG. CO. Booth 209

JFS variable speed transmission. Conveyors, elevators and crushers for industrial and power plant uses.

Representatives: D. B. Piersen, president; C. H. Adamson, secretary; R. S. Jacobsen, engineer; T. R. Ruddy, A. Mellquist, F. W. Kenzler, L. V. Lindquist, sales department.

STERLING ENGRG. & MFG. CO. Booth 218

Working model of Sterling non-tilting, lifting return trap.

Representatives: Charles G. Stebbins, E. Sherman Hall, Boston; Robert E. Beagle, Chicago manager.

STOCKHAM PIPE & FITTING CO. Booth 201

Display of cast steel flanged fittings and flanges, heavy oil malleable fittings, standard malleable fittings and flanged cast-iron fittings.

Representatives: D. W. Stockham, vice-president; Irving D. Lyon, sales engineer; Harry N. Hall, advertising manager; A. J. Bird, Walter G. Winburn, salesmen.

STROM BALL BEARINGS CO. Booth 23

Single and double roll radial and angular contact bearings, adapter type and thrust ball bearings with moving exhibit to show smooth operation.

Representatives: M. E. Monk, sales manager; H. N. Parsons, chief engineer; Miss Cora C. Smith, advertising and sales promotion manager; E. P. Schmidt, H. R. Higgins, E. H. Rohn, sales engineers; L. Anderson, service engineer; Charles Nelson, chief draftsman.

THE STRONG-SCOTT MFG. CO., Minneapolis, Minn. Booth 186

Unipulvo unit pulverizer with latest improvements and photographs showing installation and operation of the equipment.

Representatives: A. W. Strong, president; Homer L. Rank, sales manager; H. G. Lykken and A. E. Canfield, combustion engineers; George W. Heald, Chicago manager.

B. F. STURTEVANT CO. Booths 205-7

Induced draft fans, plate and tubular type air preheaters, stage and coal burning blowers, Windovane ventilating fans and unit ventilators.

Representatives: Fred Herlan, vice president and general manager; Messrs. Ekblom, Hall, Horsefield and Hamilton, sales engineers.

THE SUPERHEATER CO. Booths 127-8

Elesco superheaters as used in recent power plants for 385 lb. and 735 deg.; also special design for 1400 lb. and 735 deg.

Representatives: R. M. Ostermann, vice president; C. H. True, vice president; R. M. Gates, manager industrial department; R. S. Cooper, W. H. Armacost, T. F. Birmingham, A. H. Chas. Dalley, C. W. Gordon, V. Weaver Smith.

THE SWARTWOUT CO. Booths 52-3

High pressure feedwater regulation with differential valves for varying excess pressure to each boiler; steam traps and steam and air separators; exhaust heads, feedwater heaters; ventilators; return and lifting traps; feedwater regulators; feed pump governors; master control reducing valves, drainage controls, differential pressure valves, relief valves and heat controls.

Representatives: D. K. Swartwout, Sr., president; D. K. Swartwout, Jr., vice president; J. M. Barrett, vice president; L. P. Russon, assistant general sales manager; C. A. Webster, G. M. Fritze, Cleveland; C. W. Foster, E. H. Bolton, Geo. S. Montgomery, Chicago.

W. O. & M. W. TALCOTT, INC. Booth 336

Belt fasteners for leather belting and general use; clinching fasteners and special conveyor fasteners for belts from ⅛ to 1 in. thick; tests of fasteners in leather and rubber belting; spring steel fasteners for rubber or canvas belt which has to run over and under alternate pulleys.

Representatives: W. O. Talcott, president and treasurer; M. W. Talcott, vice president and secretary.

THE TERRY STEAM TURBINE CO. Booth 422

Terry wheel turbine for 200 lb. steam pressure and 50 lb. back pressure, for auxiliary and industrial machinery drive; 500-kw. turbine rotor for generator drive, for operation up to 125 lb. back pressure and for bleeder or mixed pressure operation; standard flexible shaft coupling suitable for all types of power equipment.

Representatives: R. L. Thomsen, sales manager; B. H. Wood, publicity manager; J. J. Somes, Chicago manager.

THE TEXAS CO. Booths 428-9

The manufacture and use of Texaco industrial oils.

Representative: N. H. Steindler, in charge of engineering, Chicago.

THOMAS PUMP CO. Booth 468

Quimby screw pumps, Aurora cellar drainer, centrifugal and high head pumps and Pulsometer steam pump.

Representatives: J. M. Thomas, president; S. J. Thomas, treasurer; L. J. Bell, sales engineer.

THE TIMKEN ROLLER BEARING CO. Booths 414-5

Railway journal boxes in roller bearing types, steel mill roll bearings, single and double row bearings for electric motors, bearings suitable for general machinery use.

Representatives: L. M. Klinedinst, G. D. Thewlis, R. P. Proffitt, R. W. Ballentine, G. W. Curtis, R. P. Kelley.

THE TRANE CO. Booths 143-4

Concealed and visible heat cabinets designed to be used in place of steam or hot water radiators.

Representatives: William S. Bilyeu, sales manager; P. D. Bennett, Chicago manager.

THE TRI-LOK CO. Booth 77

Tri-Lok ventilated flooring and safety steps as used for boiler room walkway and stair treads; concrete floor armoring; shake-out table for foundry use; flush type sidewalk or transformer vault door and ventilated openings for sidewalks; standard sizes, styles and depths of Tri-Lok.

Representatives: A. J. Diebold, president; Thomas M. Gregory, vice president and general manager; A. J. Loeffler, treasurer; H. Nagin, secretary; W. McC. McKee, sales manager; D. H. Skeen and E. U. Titus of D. H. Skeen & Co., Chicago.

TROY ENGINE & MACHINE CO. Booth 197

Small engine with glass panels to show operation of lubrication and admission valve, also detailed parts.

Representative: J. H. Hopp, Chicago.

UEHLING INSTRUMENT CO. Booth 149

Electrically operated Apex CO_2 recorders and indicators, combined barometer and vacuum recorder with automatic log of steam turbine performance.

Representatives: Ernest E. Lee, J. L. Higgins, J. L. Maher, S. E. Oswald, C. J. Schmid.

THE UNISHEAR CO., INC. Booths 416-7

Metal cutting devices for working out complicated designs, both interior and exterior outlines in complicated pattern.

Representatives: H. Steindorff, president; H. C. Konrad, western manager; Max Carsen, Chicago manager.

UNITED CONVEYOR CORP. Booth 194

Pneumatic ash conveying and steam jet ash conveying systems; cast iron and hard glazed tile ash tanks; air-tight cast iron ash pit doors.

Representatives: E. B. Tolman, Jr., president; E. G. Farrand, general manager.

VASTINE SALES CORP. Booth 208

Furnace fire observers in models for large and small wall types, door types, ignition point types, air cooled and water cooled walls.

Representatives: R. P. Vastine, secretary; C. H. Samuelson.

HENRY VOGT MACHINE CO. Booths 424-5

Drop forged steel valves and fittings for high steam pressures and temperatures and for extra high hydraulic pressures. Details and method of installation of water tube boilers.

Representatives: W. S. Cannon, assistant manager, drop forged steel valves and fittings department; W. A. Jackman; E. J. Dreyer, boiler sales department.

VULCAN SOOT CLEANER CO. Booth 195

Vulcan self-contained operating head with monel trim, Ratchet operating head and Crodon corrosion-resisting elements.

Representatives: S. W. Linaker, vice president and general manager; William C. Ihde, sales manager; D. E. Hibner, Jr.

THE WALSH & WEIDNER BOILER CO. Booths 176-7

Sectioned parts of boilers, including 54-in. steam drum for 450 lb. pressure with special construction features; forged steel sectional headers for 500 and for 1600 lb. pressure; covered water wall for furnace construction; high pressure water gage; cross section parts of various equipment.

Representatives: A. C. Weigel, eastern and export manager; L. G. Haller, assistant sales manager; Myron D. Kizer, Chicago; Percy Jackson.

WALWORTH CO. Booths 98-9, 100-1
Sigma steel gate valves and fittings for high pressures and temperatures, including a motor-operated valve for 900 lb. pressure and gate, globe and check valves for other pressures. Eight-inch sectioned steel tee with risers cast integral; Stillson wrench display showing unique testing of a 14-in. wrench.

Representatives: W. C. Mattox, advertising manager; F. M. Churchill, advertising department; F. W. Duemler, manager; G. R. Galbraith, H. C. Nannen, engineering products division, New York; W. H. Weber, engineering products division, Chicago; A. J. Mather, vice president and manager of Kewanee works; A. O. Brungardt, manager of Boston works; Harry McCarthy, assistant chief engineer; R. W. Rounseville, general superintendent of Kewanee works; C. W. Watson, manager, William Robinson, Chicago branch; J. M. Gamble, Kewanee works; W. J. Lewis, Greensburg works; H. G. Lambert, Boston works.

WARREN WEBSTER & CO. Booths 41-2
Webster systems of steam heating, including the R system, series 78 traps, No. 026 drip traps and the latest developments and applications.

WEBER INSULATIONS, INC. Booth 235
Industrial and house insulation for piping and construction work.
Representatives: Louis Weber, Sr., president.

THE WELLMAN-SEAVER-MORGAN CO. Booths 113-14
Wellman supertest gate and globe valves for high pressures and temperatures with special design of seat and valve cage, also other equipment illustrated by photographs.
Representatives: Fred Stadelman, secretary; Harry Warriner, manager of supertest valve sales department.

WESTINGHOUSE UNION BATTERY CO. Booth 223
Heavy duty batteries for power plant use; individual cells of various sizes; auxiliary wood case types and assortment of connecting devices.
Representatives: Roger Chauveau, western sales manager; H. R. Taylor, manager of power sales.

WESTON ELECTRICAL INSTRUMENT CORP. Booth 305
Model 44 electric tachometer; panel and portable type of alternating and direct current instruments for electromotive force, currents and electrical energy.
Representatives: P. A. Westburg, J. F. Inman, K. Gray, M. Huffnagle.

C. H. WHEELER MFG. CO. Booths 94-5
Three-stage and two-stage Radojet air pumps for high vacuum, cross section model of two-stage air pump, cross section of Leach Fracto-control condenser and drawings and photographs of condenser and auxiliary installations.
Representatives: C. H. Wheeler, Jr., vice president and general manager; G. L. Kothny, executive engineer; Robert Kerr, chief engineer; Frank Wheeler, Chicago manager; John Dobson, Philadelphia.

WICKES BOILER CO. Booth 446
Lantern slide demonstration of shop operations in the construction of boilers and actual installations; section of a Wickes patented single joint header as used in cross drum boilers, also of Wickes three-drum curved tube boiler.
Representatives: E. B. Wickes, vice president; H. E. Aldrich, general manager; J. R. Fortune, sales manager; C. F. Wilson, district manager; M. S. Nelson, sales engineer; E. A. Dunton, service engineer.

WILLIAMS TOOL CORP. Booth 400

L. J. WING MFG. CO. Booth 318
Turbine driven blower for supplying forced draft to individual boilers; motor-driven blower for supplying forced draft to low pressure heating boiler; centrifugal turbine blower for air pressures above 6 in. water pressure, used with gas producers and pulverized coal; Featherweight unit heater for industrial buildings. Scruplex exhauster for removing heated air, fumes and gases.
Representatives: H. S. Wheller, vice president; V. H. Carples, secretary and treasurer.

WORTHINGTON PUMP & MACHINERY CORP. Booths 48-9
Steam jets as used for inter and after cooler work in large power plants; special high pressure oil line centrifugal pump and smaller centrifugal pumps.
Representatives: H. E. Troutman, Chicago district sales manager; F. E. Widman, P. A. Mack.

WRIGHT-AUSTIN CO. Booth 435
Standard line of separators, water columns and steam traps; Airxpel bucket trap; Kleervu gage glass protector; Crescent try cock.
Representatives: C. B. Walter, president; H. R. Patterson, Chicago manager.

YARNALL-WARING CO. Booths 43-4
Yarway blow-off valves for 1350 lb. pressure, working model of spray pond equipped with involute spray nozzles and fittings, high and low pressure water columns with Sesure inclined water gages, Lea V-notch meter, hydraulic valves, pipe joint clamps and Holtite clamps.
Representative: H. J. Moyer, Chicago manager.

Michael Pupin Receives Washington Award

AT A DINNER given February 2 at the Palmer House, Chicago, Dr. Michael I. Pupin was presented with the Washington Award for the year 1928 which was founded by John Watson Alvord for preeminent service in promoting public welfare.

Dr. Pupin, who is professor of electro mechanics and director of Phoenix Research Laboratory at Columbia University is of Serbian parentage, having come to America at the age of fifteen and worked his way through Columbia University, later taking graduate work at Cambridge and Berlin, where he received a Ph. D. under Helmholtz.

Among his outstanding works were the application of tuned circuits to the selective electrical reception of signals and the development of the resonant system now used as the basis of all radio broadcasting. He also did noteworthy research work in rectifying alternating current and rapid x-ray photography. His method of loading telephone circuits made long distance telephony possible at a time when it was most needed. His development of a method of submarine detection using high frequency sound waves concentrated in a beam like that of a searchlight was one of his contributions to science during the war.

R. F. Schuchardt, as chairman of the Washington Award Commission, was the toastmaster of the evening and among those on the program were Rufus W. Putnam, President of the Western Society of Engineers; Dr. A. H. Compton of the University of Chicago, recent recipient of the Noble Prize; Dr. A. N. Talbot, Past President, American Society of Civil Engineers; Dr. William Kelly, Past President, American Institute of Mining and Metallurgical Engineers; John Lyle Harrington, Past President, American Society of Mechanical Engineers, and Bancroft Gherardi, President, American Institute of Electrical Engineers.

The Award is administered by the Western Society of Engineers on the recommendation of a commission representing the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers and Western Society of Engineers.

Recipients of the Award in former years were Hon. Herbert C. Hoover, 1919; Robert W. Hunt, 1922; Dr. Arthur N. Talbot, 1923; Jonas Waldo Smith, 1925, and Dr. Orville Wright, 1927.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Reeves Announces Improvements on Transmission

REEVES PULLEY CO., Columbus, Indiana, has announced several major improvements in the Reeves variable speed transmission. These improvements are intended to make the transmission stronger, more compact and more efficient. First among them is a new double-block, center-pull V-belt, designed to give over twice the surface contact against the driving disks of the transmission. Through this double-block construction, shown in Fig. 1, the center line of pull is at the exact center of the belt body, and the load is evenly distributed above and below. The end tips of the belt blocks are shaped by a special process to conform exactly to the curved surface of the driving disks, giving a snug, uniform fit to insure positive flow of power at all speeds. The new belt can be run at slack tension, which lengthens the lift of the belt and reduces the load on the driving parts.

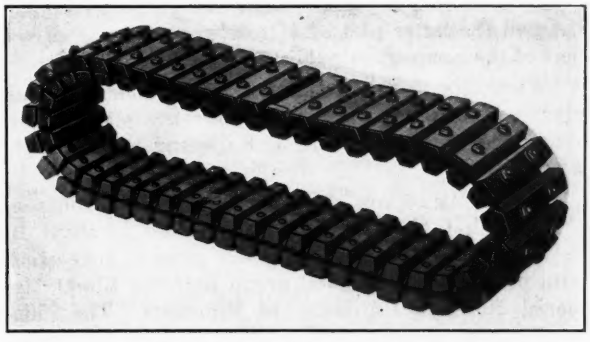


FIG. 1. NEW DOUBLE-BLOCK V-BELT FOR REEVES TRANSMISSION

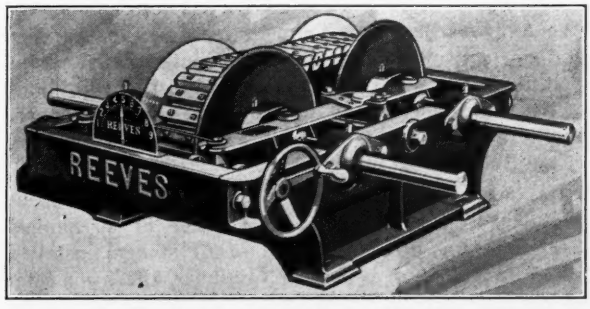


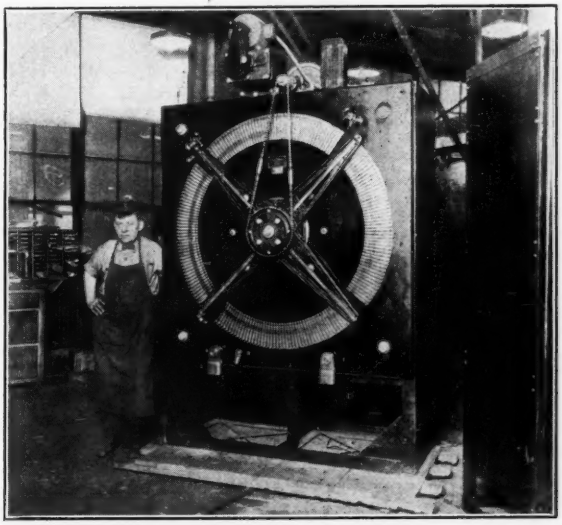
FIG. 2. NEW DESIGN OF UNIT INCREASES STRENGTH AND DECREASES SIZES

Also, the new transmission has a different type of splice-block of the double-pin interlocking type with cast aluminum blocks and tool steel plates. The transmission has been reduced in size by setting the frame bearing housings in recessed grooves in the frame sides. This brings the bearing housings closer together and makes the drive shafts stronger and more rigid. The over-all length of the transmission has been materially reduced; also, the feet of the new frame are planed. The bore of the disk hub is now grooved spirally, providing more uniform and thorough lubrication to all parts of the disk hub bore, shaft, and driving keys.

Standard equipment on the new Reeves transmission includes a handy speed indicator mounted right on the transmission frame so the operator may know at a glance the approximate speed at which the transmission is running.

Large Cutler-Hammer Motor-Operated Field Rheostats

IN THE attached photograph is shown one of the largest motor-operated field rheostats ever built by The Cutler-Hammer Mfg. Co., Milwaukee, Wis.



FRONT VIEW OF ONE SECTION; OTHER SECTION IS BOLTED TO BACK OF IT WHEN INSTALLED

The rheostats were designed for one of the large public utility companies in the South and are used with generators developing from 22,500 kv.a. to 27,500 kv.a. They are 60 in. wide, 80 in. high, not including the

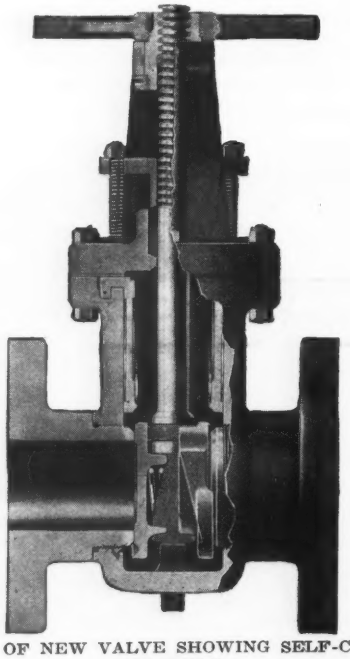
motor drive, and 77 in. deep. Each panel has 188 segments with 180 steps of resistance. The segments are divided into four sections which are staggered in relation to each other so that 175 current changes are obtained. Each rheostat has a maximum capacity of 1250 amp.

The rheostats are built in two sections for ease in shipment and are bolted together when installed. The driving motor is controlled by push buttons placed at convenient locations. All levers are interlocked to prevent overtravel. Provision is made for operating the rheostats manually when necessary.

Kelly Company Announces New Valve

EMBODYING MANY interesting features of design a gate valve has recently been patented and placed on the market by the Kelly Co. Chicago, Ill., under the name of the Kelly Nuway gate valve. The new valve was designed by P. J. Kelly after 33 yr. of close association with valve conditions and requirements. Its features include self-cleaning seats, design for positive valve disc protection when open and elimination of pockets, use of replaceable inserts and seats and the adaptability of a standard body design to any type of service by the use of the proper insert-screw, flange, hub or spigot.

Probably the most important of these improvements is the self-cleaning feature. Each time the Kelly valve



SECTION OF NEW VALVE SHOWING SELF-CLEANING FEATURE

is operated, a reciprocal scraping of moving parts takes place. This, combined with the elimination of pockets, is designed to keep the valve clean at all times, to prevent misalinement of parts, and to insure maximum operating efficiency. Seat rings are eliminated in the new design by the use of removable and replaceable inserts with which the seats are integral.

News Notes

UNDER THE AUSPICES of the N. D. H. A. a short study course in district heating will be held at Purdue University from May 21-26, 1928, inclusive. Work is intended primarily for employes of district heating companies, but as the work is quite broad in character, the attendance will not be limited to members of the association, but will be open to everyone. A similar course held last year was well attended and it is expected that the attendance this year will be much greater. A detailed announcement will be made later of the exact arrangements.

ORDERS RECEIVED by the General Electric Co., Schenectady, N. Y., during the year 1927 amounted to $309,784,623 compared with $327,400,207 for 1926, a decrease of 5 per cent, President Gerard Swope has announced.

For the three months ended December 31, orders amounted to $76,708,532 compared with $80,406,570 for the final quarter of 1926, also a decrease of 5 per cent.

Sales billed and earnings for the year will be announced the latter part of March, when the annual report of the company is published.

WISCONSIN POWER & LIGHT CO., Madison, Wis., has plans under way for a new hydroelectric plant in the vicinity of Beloit, Wis. E. J. Kallevang is chief engineer.

STATE COMMISSION of Administration and Finance, State Capitol, St. Paul, will call for bids in about 10 days for a new central steam power house in connection with proposed new hospital group near the Elliott Memorial Hospital, University of Minnesota. The Pillsbury Engineering Co., 2344 Nicollet Avenue, Minneapolis, Minn., is engineer.

MERGER OF THE Andrews-Bradshaw Co. of Pittsburgh, Pa., with the Blaw-Knox Co. has been announced. The Andrews-Bradshaw Co. manufactures the Tracyfier and no change in its organization is contemplated except that its products will be manufactured in the main plant of the Blaw-Knox Co. at Blawnox, Pa., near Pittsburgh, and it will operate as the Andrews-Bradshaw Division of the Blaw-Knox Co.

ACCORDING TO the latest report from the Department of Commerce, Washington, D. C., sale of mechanical stokers increased from a total of 67 stokers installed under 16,955 hp. of boilers in November, 1927, to a total in December, 1927, of 83 stokers under 32,202 hp. of boilers. Of the number sold in December, 29 were under 4799 hp. of fire-tube boilers and 54 under 27,403 hp. of water-tube boilers. For the year 1927 a total of 1261 stokers were sold under 462,918 hp. of boilers. Of this number 399 stokers were installed under 60,708 hp. of fire-tube boilers and 862 under 402,210 hp. of water-tube boilers.

ANNOUNCEMENT IS MADE that work is under way on the site of the new Hams Hall Power Station near Birmingham, England, the first section of which is to have a capacity of 60,000 kw. The site has been laid out to accommodate four stations of 210,000 kw. each or a total of 840,000 kw. The first installation will consist of two 30,000-kw. steam turbines with Babcock & Wilcox boilers of 200,000 lb. per hr. capacity each, fired by pulverized coal. An installation of 25 Riley Atritas, each of 9000 lb. per hour capacity, will supply this coal. The main

contract for the station itself has been let to International Combustion Engineering Corp., Ltd., while General Electric Co. will supply the turbines and the electrical equipment. The condensing arrangement will include some very large ferro-concrete cooling towers. Power will be generated at 11,000 v. and stepped-up to 33,000 v. for transmission into Birmingham.

Books and Catalogs

FLUID METERS, Their Theory and Application. Part I, Second Edition, published by the American Society of Mechanical Engineers, New York, N. Y.

This is the first part of the report of the A. S. M. E. Special Research Committee on Fluid Meters organized in 1916. The report takes the form of a reference book on fluid meters of all kinds, and contains not only such practical instruction and information including formulas, constants, etc., as may be needed by the actual or prospective user, but also more general information such as the physical principles of design and operation which may be useful to students and designing engineers.

It gives a complete treatment of the subject, covering not only actual experimental data, but outlining a new presentation of the subject of fluid flow with a mathematical analysis which is much more specifically applicable than is Bernoulli's theorem. The use of this method is especially practical, in that it makes possible the reconciliation of data obtained from experiments with the Venturi tube and the thin plate orifice, which were formerly thought to be irreconcilable.

ELECTRIC ELEVATORS; Their Design, Construction, Operation and Maintenance, by F. A. Annett. First edition, cloth, size 6 by 9 in., 448 pages, 351 illustrations; McGraw-Hill Book Co., Inc., 370 7th Ave., New York. Price $5.00.

This is a thorough discussion of the design, construction, operation and maintenance of electric elevators of all types for engineers, architects and building superintendents. While space does not permit a description of all types of elevators, in the first two chapters a sufficient number of types has been considered to give the reader a fairly comprehensive idea of the field and what may be expected in both direct and alternating current applications. Automatic leveling or automatic landing types of machines with variable voltage or other types of control systems are treated at considerable length. Since the latest designs of elevators represent only a small part of those in use, it has been deemed advisable to include in a general way, all types of elevators from the old belt-driven machine to the high speed, automatic-leveling machine with signal control. Considerable space is given to the control of elevator equipment.

PROPOSED TENTATIVE American Standards for Symbols for Hydraulics have been prepared by Sub-Committee No. 2 of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations of the American Engineering Standards Committee. The tentative standards have received the approval of the sub-committee and are now being distributed by the A. E. S. C. and five sponsor bodies for criticism and comment. Communications should be addressed to Preston S. Millar, Secretary of the Sectional Committee of Scientific and Engineering Symbols and Abbreviations, Electrical Testing Laboratories, 80th and East End Ave., New York, N. Y.

EDWARD VALVE & MFG. CO., East Chicago, Ind., has just issued a well-illustrated, 144-page catalog describing its products. Complete details regarding non-return, stop and check valves of cast steel for high temperatures for pressures up to 1350 lb. are given. Details are given of the recently developed forged steel designs of globe and check valves in the smaller sizes and of the Ferac line. Data regarding flanges are attractively presented and, as the book is 8½ by 11 in. in size, convenient tables and dimension drawings can be included as well as data on the valves. These data should prove of general interest to engineers.

GARRATT-CALLAHAN CO., Chicago, New York, and San Francisco, recently published a new booklet entitled "Magic." This booklet tells of the development since 1902 of "Magic" Boiler Preservative, "the only product they manufacture, and the only product they sell." The booklet gives suggestions, also engineering tables on heat losses from accumulated scale in boilers. It will be furnished upon request to nearest office of the company.

THE BABCOCK & WILCOX CO., New York, has issued a bulletin describing its new return-bend wrought steel economizer, in which all bends and joints are outside the economizer casing. It also describes B. & W. No. 80 fire brick in a 4-page booklet.

SPEED REDUCERS of both spur gear and worm gear types for ratios up to 800,000 to 1 are described in Bulletin A by Albaugh-Dover Mfg. Co., Chicago, Ill.

JENKINS BROS., 80 White St., New York, N. Y., is issuing a folder describing the Jenkins forged steel drilling valve, designed for pressures up to 4000 lb. per sq. in.

IN A RECENT 4-PAGE FOLDER, The Bigelow Co., New Haven, Conn., discusses and illustrates new types of Bigelow water wall surfaces, including the water cooled bridge wall and slag screen.

JAMES G. BIDDLE, 1211-13 Arch St., Philadelphia, Pa., in bulletin No. 1165 just issued, describes the new Megger Ground Resistance Tester.

THE HAYS CORP., Michigan City, Ind., in a new 16-page well illustrated bulletin No. R L-27 describes the Hays CO_2 and Draft Recorder, simplified and improved. Data for installing and operating the recorder are given.

AMERICAN FLUID MOTORS CO., Philadelphia, Pa., has just issued a 32-page, well illustrated bulletin, catalog C, describing in detail the Hele-Shaw hydraulic pumps and motors for the application of high pressure hydraulic power.

THE NEW KEYSTONE pneumatic safety lubricator is discussed in a recent folder by the Keystone Lubricating Co., 21st, Clearfield and Lippincott Sts., Philadelphia, Pa.

INTERNATIONAL COMBUSTION ENGINEERING CORP., 200 Madison Ave., New York City, in publication IC-3 describes the KSG process for low temperature carbonization of coal. In publication S-1 description is given of an installation of the Sulzer system for dry quenching of coke at the plant of the Rochester Gas & Electric Corp.

Power Plant Construction News

Ark., Camden—The Camden Ice & Coal Co. has engaged George E. Wells, Security Building, St. Louis, Mo., consulting engineer, to prepare plans for the rebuilding of its local ice and cold storage plant, including boiler house recently destroyed by fire with loss of about $45,000. The plant will have capacity of 30 tons per day.

Calif., Richmond—The Certain-Teed Products Co., manufacturer of roofing, etc., plans the installation of power equipment, elevating and conveying equipment in connection with a proposed expansion program at its local plant. The entire project will cost about $110,000. Ralph Bergen is plant manager.

Colo., Boulder—The City Council is said to be planning the installation of pumping equipment and power apparatus in connection with proposed extensions in the municipal waterworks. A bond issue of $50,000 is being arranged for the project. Earl Devalon is city engineer.

Ga., Woodland—The Columbus Electric & Power Co., Columbus, Ga., is said to be planning the construction of an 11,000-volt power transmission line to Woodland and vicinity, about 30 miles, with substation for local service.

Ill., Libertyville—The Common Council is considering the installation of a pumping plant for the municipal waterworks, estimated to cost about $40,000. Kelker, De Leuw & Co., 111 West Washington Street, Chicago, Ill., are engineers.

Iowa, Des Moines—The Western Silo Co., 5130 Shriver Avenue, is reported planning the installation of a boiler house in connection with proposed rebuilding of plant recently destroyed by fire with loss of about $75,000. J. Martin is president.

Iowa, Iowa City—The Iowa City Light & Power Co. plans extensions and improvements in its power plant at Coralville, near Iowa City, including installation of a 500-hp. boiler unit, mechanical stoker, coal-handling equipment and auxiliary apparatus. The program will cost close to $60,000. C. H. Myers is general manager.

Iowa, Sioux City—The City Council is planning the construction of an addition to its Lowell pumping station, and installation of new equipment; Philip Carlin is superintendent.

Kan., Salina—The H. D. Lee Flour Mills Co. plans the installation of power equipment, conveying machinery, etc., in connections with its proposed new grain elevator. The entire project will cost about $150,000.

Minn., Moorhead—The Common Council has called a special election, March 10, to approve bonds for $35,000, the fund to be used for extensions and betterments in the municipal electric power plant and waterworks, including equipment installation.

Minn., Rochester—The Board of Education is planning the construction of a new central power plant at the high school estimated to cost $100,000, with equipment. A bond issue is being arranged. S. L. Seaman is clerk.

Minn., Willmar—The City Council is selecting an engineer to prepare plans and specifications for proposed extensions and improvements in the municipal electric light and water plant. Estimates of cost will soon be made. Hans Gunderson is city clerk.

N. Y., New York—The Union Railway Co., 2396 Third Avenue, will begin the erection of a one-story steam power house at its shops at West Farms Road and 172nd Street, in connection with an expansion and improvement program. O. H. Faile & Co., 441 Lexington Avenue, are engineers.

N. Y., Rome—The Department of Mental Hygiene, Capitol Building, Albany, N. Y., is asking bids until Feb. 8, for pumping equipment for fire protection, including reservoir, at the state school at Rome. Plans at the office noted. Lewis M. Farrington is secretary.

N. C., Wadesboro—The West Knitting Co., Syracuse, N. Y., plans the construction of a power plant at its proposed local mill, and will soon begin work. R. C. Biberstein, 1614 Elizabeth Avenue, Charlotte, N. C., is engineer. The entire project is reported to cost in excess of $50,000.

Ohio, Cleveland—The Gustav Schaefer Wagon Co., 4180 Lorain Avenue, is said to be planning the installation of a boiler plant in connections with proposed rebuilding of its works recently destroyed by fire with loss reported in excess of $300,000, including equipment. Henry G. Schaefer is head.

Ohio, Youngstown—The Baltimore & Ohio Railroad Co., Baltimore, Md., is planning the construction of a steam-operated power plant in conjunction with a new engine house and other mechanical buildings near Youngstown. The entire project will cost close to $750,000.

Okla., Tulsa—The C. J. Patterson Corporation, 4050 Penn Street, Kansas City, Mo., will install traveling ovens, power equipment, conveying machinery and other equipment in its proposed baking plants at Eleventh and Utica Streets, Tulsa; and on West Eighteenth Street, Oklahoma City, Okla., each to cost about $80,000.

Okla., Tulsa—The Southwestern Sales Corporation, Atlas Life Building, has approved plans for the erection of a one-story generating plant in the Reservoir Hill section, and will proceed with work at once. Charles S. Dilbeck, Tulsa Building & Loan Association Building, is engineer.

Pa., Milroy—The Gold Hosiery Co., 190 Broadway, New York, plans the erection of a one-story boiler plant at its proposed local mill. The entire project will cost about $130,000. Levy & Berger, 375 Fulton Street, Brooklyn, N. Y., are architects.

Pa., Philadelphia—The Quaker City Cold Storage Co., Water and Spruce Streets, is having revised plans drawn for its proposed multi-story cold storage and refrigerating plant on Delaware Avenue, near Spruce Street, estimated to cost close to $1,000,000 with equipment. The Ballinger Co., Twelfth and Chestnut Streets, is architect and engineer. It is understood that new bids will soon be asked.

R. I., Central Falls—The Central Falls Mfg. Co., is planning the installation of electric power and boiler equipment in connection with proposed rebuilding of the portion of its woodworking plant recently destroyed by fire with loss estimated at close to $100,000. Joseph A. Bonvouloir is manager.

Tenn., Elizabethtown—The American Glanzstoff Corporation will build a two-story power house and boiler plant, 65 by 112 ft. and 35 by 112 ft., at its new local rayon mill, for which plans have been drawn by Lockwood, Greene & Co., 100 East Forty-second Street, New York, architects and engineers. The entire project will cost more than $1,000,000. Headquarters are at 180 Madison Avenue, New York.

Texas, Houston—The Houston Lighting & Power Co., has plans under way for a new power substation on the Richmond Road, estimated to cost close to $200,000, with equipment.

Utah, Price—The Utah Asphalt Corporation, care of John F. Cregon, Third Street and North Grand Avenue, Pueblo, Colo., consulting engineer, is considering the construction of a power house in connection with a rock asphalt mining plant on properties about 30 miles from Price. The complete project will cost approximately $1,000,000 with machinery.

Utah, Salt Lake City—The Smokeless Fuel Co., Salt Lake City, plans the construction of a power house at its proposed local fuel plant at Twenty-first Street South and Eighth Street West. The complete project is reported to cost in excess of $750,000.

Va., South Norfolk—The A. S. Lee & Sons Co., South Norfolk, is reported planning the installation of a boiler plant in connection with the proposed rebuilding of its local lime and fertilizer mill, recently destroyed by fire with loss of about $50,000, including equipment.

Wash., Wenatchee—The Cascade Power Co., 2839 West Florida Street, Seattle, Wash., has made application for permission to construct and operate hydroelectric generating plant on the Wenatchee River, Chelan County, reported to cost in excess of $300,000, with transmission system.

Wis., Madison—The Water Department, Leon A. Smith, superintendent, is said to be planning an early call for bids for an electric-operated pumping unit for the municipal waterworks.

Wis., Wauwatosa—The F. Hartung Co., Swan Road, is said to be planning the purchase of industrial motors, belting and other power equipment for installation at its stone-crushing plant. An expansion program will be carried out.

Wis., West Allis—The National Ice & Coal Co., affiliated with the Random Ice & Coal Co., Milwaukee, Wis., has superstructure work under way for a one-story ice-manufacturing plant, 120x150 ft., to cost about $45,000, with equipment.